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DEPARTMENT OF THE ARMY FIELD MANUAL

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THE ENGINEER SOLDIER'S HANDBOOK

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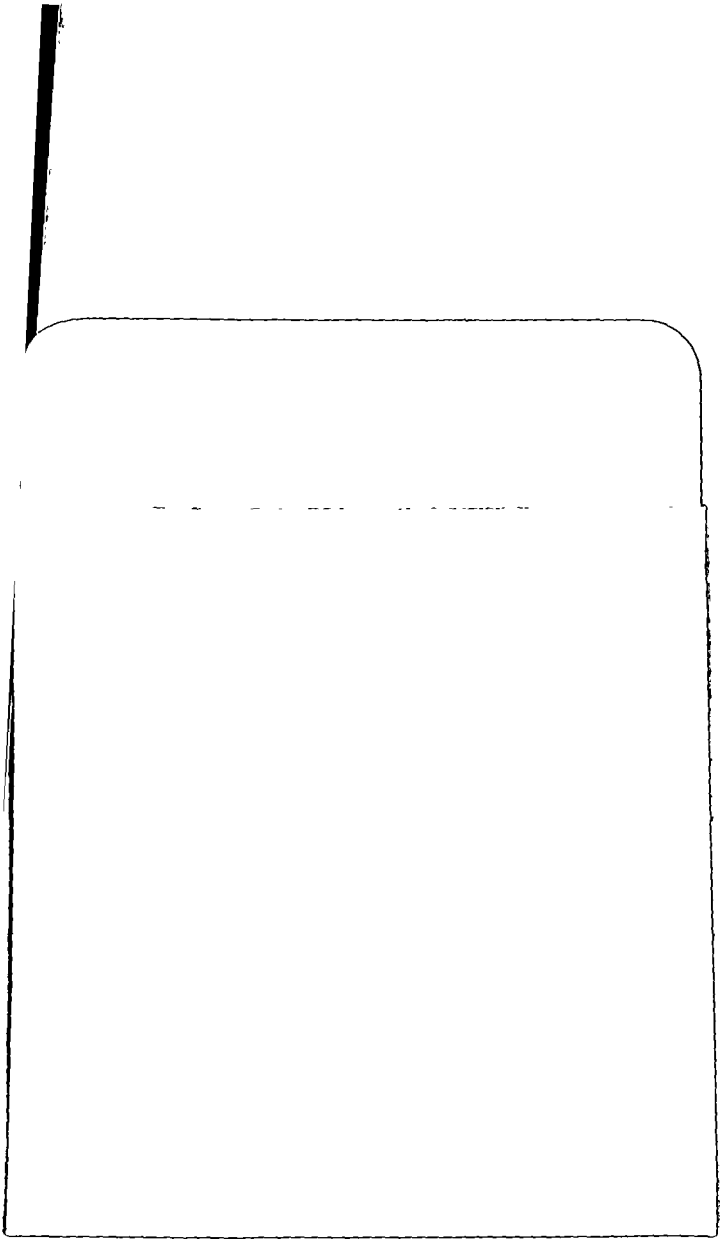

FIELD MANUAL
No. 5–13

HEADQUARTERS
DEPARTMENT OF THE ARMY
WASHINGTON, D. C., *31 July 1964*

THE ENGINEER SOLDIER'S HANDBOOK

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CHAPTER 1

INTRODUCTION

1. Purpose and Scope

a. This manual is for the basic engineer soldier to use in improving his abilities, strengthening his talents, and developing proficiency in basic engineer subjects. Mastery of its contents and acceptance of its guidance will furnish the professional competence on which the engineer soldier builds his pride and integrity. The material presented in this manual is applicable to both nuclear and nonnuclear warfare.

b. This manual covers skills needed in using tools and equipment, instruction in elementary rigging, and the fundamental uses of explosives and demolitions. The practices and techniques of camouflage, reconnaissance, communication methods, and survival knowledge are also covered. Discussions are included on construction procedures for roads, bridges, field fortifications, and obstacles.

c. Users of this manual are encouraged to submit recommended changes or comments to improve the publication. Comments should be keyed to the specific page, paragraph, and line of text in which the change is recommended. Reasons

should be provided for each comment to insure understanding and complete evaluation. Comments should be forwarded directly to Commandant, U. S. Army Engineer School, Fort Belvoir, Va.

2. Organizing the Corps of Engineers

a. In 1775 the Continental Congress provided for a chief engineer with two assistants "at the Grand Army." General Washington appointed Richard Gridley as the first Chief Engineer. Gridley, in accepting his appointment, declared himself for the colonies against his mother country, England. He thus sacrificed his material holdings in England and his citizenship. Three years later the Continental Congress authorized three companies of sappers and miners. These engineers built the siege works and fortifications at Yorktown that brought final victory for the colonies. After the British government acknowledged the independence of the colonies, the American army was reduced to 80 men and the engineer units dissolved. In 1802, the present Corps of Engineers was established when Congress abolished the old corps of artillery and engineers. The act of Congress designated the Corps as a military academy with headquarters at West Point, N. Y.

b. The traditional turreted castle (fig. 1) was first authorized as the Corps of Engineers insignia in 1840. Previously it had been worn as part of the uniform of the Corps of Cadets at West Point. At that time, the U. S. Military

Academy was under supervision and direction of the Chief of Engineers. Selection of the turreted castle as the Army Engineer insignia followed the first major construction undertaking of the Corps—the building of a system of castle-like fortifications for the protection of harbors along the Atlantic coast. Claims have been made by some that the castle insignia was based on the design of the French Engineer School at Fontainebleau or on a replica of the gate of the city of Verdun. There is no historical evidence to support this.

c. The officers of the Corps of Engineers do not wear the button with the coat of arms of the United States as is worn by all other officers of the Army. In recognition of the Corps' distinguished and outstanding record, the Corps of Engineers officer is authorized to wear the distinctive uniform button shown in figure 2. It depicts a fortification modeled after an early structure on Governor's Island in New York Harbor. The Engineer motto "Essayons" is in-

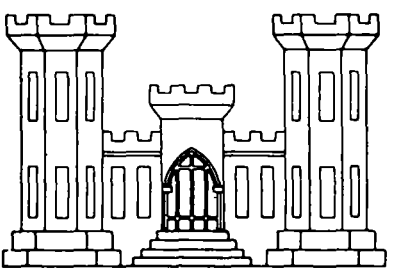


Figure 1. Engineer insignia.

scribed above the fortification and means "Let us try."

3. Development

The development of the Corps has seen engineers participate courageously and skillfully throughout many wars. During these war periods the Corps acquired responsibility for many of the functions that it has today: construction of ports, docks, roads, bridges, transportation facilities, camps, hospitals, depots, map making, camouflage, mine developments, combat support of the field forces, and water supply responsibility. World War II brought worldwide expansion to the Corps of Engineers. During this period the various types of units and teams existing today were organized. Engineer battalions became an integral part of all types of divisions, and were a

Figure 2. Engineer button worn by officers.

part of the advance element in each theater of operations. The Pacific Theater of Operations was often referred to as "an Engineer's War." In 1950, the Corps of Engineers faced the challenging assignment of building roads and bridges throughout the combat zones of Korea to permit the passage of mechanized troops. During one extended period of the Korean War, the engineers installed over 1,000 tons of bridge material a day. As in previous wars, the men of the Corps of Engineers distinguished themselves as builders and fighters in Korea, performing seemingly impossible tasks in one of the most rugged areas of the world. Figures 3 through 6 show some accomplishments of the Corps of Engineers during four wars.

4. Mission

Each member of the Corps of Engineers shares its tradition regardless of what echelon or capacity he serves. The primary mission of the Corps is to build and fight the way to victory with the finest equipment and the most modern weapons. Theories and ideas are tested in field experiments and skills are developed by constantly using what you learn. The ability and proficiency gained in the Corps are indispensable in war and essential in peace. You will be trained to perform a wide variety of skills on the battlefield, in civilian disaster areas, and wherever the nation needs the engineer's knowledge and inventives. The contrasts will be extreme, ranging from the use of ordinary field expedients and

Figure 3. Civil War engineers constructing a ponton bridge across the James River, 1864.

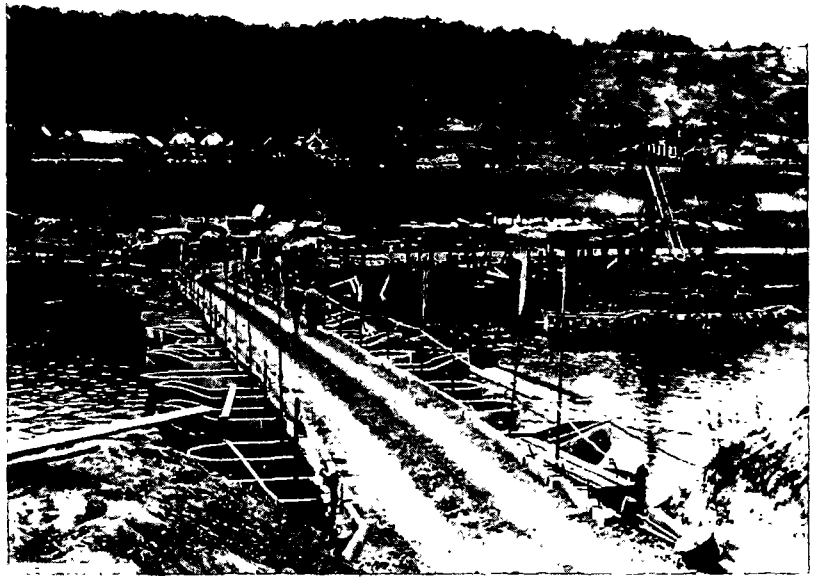


Figure 4. World War I engineers use a ponton bridge installed by them while they construct a pile bent bridge somewhere in France.

Figure 5. A convoy ascends the famous "21 curves" highway in China, built by U. S. Army Engineers in World War II.

basic fortifications to the placement of atomic demolitions in warfare. You will be involved in maneuvers of the Cold War and insurgent activities throughout the world. The material presented herein will help carry on the important missions and traditions of the Corps of Engineers.

Figure 6. Engineer soldiers, interrupted in their task of building a raft at the Han River, return fire from behind a bulldozer during the Korean War.

CHAPTER 2

ENGINEER HANDTOOLS AND POWER TOOLS

Section I. HANDTOOLS

5. Handtools

Each engineer organization is equipped with the handtools needed for accomplishing the missions normally assigned to it. For convenience in selecting tools for a particular job, they are grouped into sets, such as carpenter, demolition, and pioneer sets. Most of the tools you use are handtools and can be subdivided into seven groups as follows: (1) cutting; (2) driving; (3) drilling and boring; (4) measuring and layout; (5) digging; (6) chopping; and (7) miscellaneous. The most important tools of each group are discussed below. These discussions are only a guide, however; they are not a substitute for actual training and extensive practice. Apply the things you read here at the first opportunity.

6. Cutting Tools

a. Saws. There are several types of handsaws, each designed to perform definite cutting operations.

(1) *Types and use.*

(*a*) *Crosscut.* The crosscut saw (fig. 7) is designed for cutting across the grain of wood. It has eight or more points (number of teeth plus one point per inch). A crosscut saw with coarse teeth and a wide set is needed for cutting green, unseasoned wood. A fine toothed saw does more accurate cutting and is best for dry seasoned wood.

(*b*) *Ripsaw.* The ripsaw (fig. 8) is designed for cutting with the grain of the wood. The teeth of the ripsaw are like two rows of chisels in their action. The ripsaws in the engineer tool sets usually have 5½ points.

(*c*) *Nested saws.* Nested saws (fig. 9) have a handle common to three blades which are: a keyhole saw; a compass saw; and a plumber's saw.

1. *Keyhole saw.* The point of the keyhole saw is narrow enough to enter a ¼-inch hole. It is commonly used

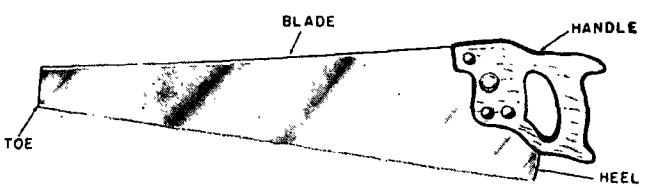


Figure 7. Crosscut handsaw.

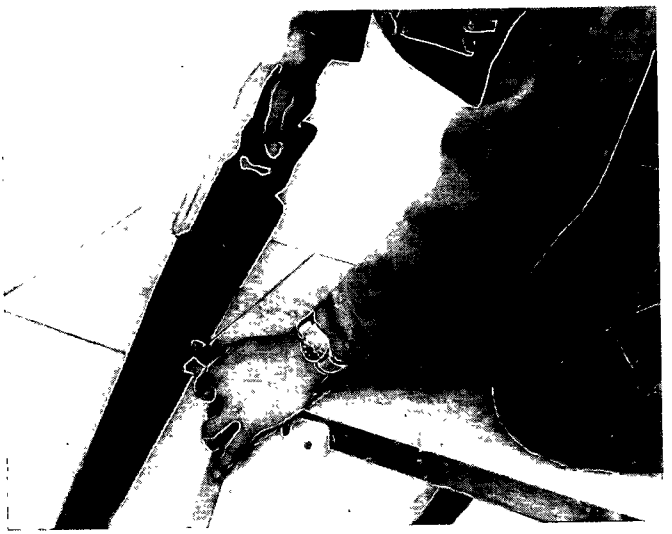


Figure 7—Continued.

for cutting keyholes in fitting locks in doors and for smaller types of work.

2. *Compass saw.* This blade is designed for sawing curves and is used also for starting cuts to be completed by larger saws, particularly interior cuts.

3. *Plumber's saw.* This is a heavy blade with fine teeth, designed for cutting nails and soft metals. The blade is thick enough to permit a woodcutting saw to pass freely

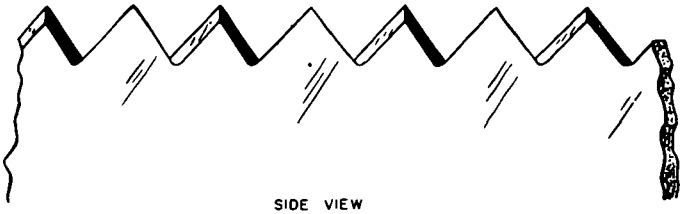


Figure 7—Continued.

through the cut it makes through a nail.

(*d*) *Hacksaw.* The hacksaw (fig. 10) is used for cutting metal. It consists of a blade and frame which has a handle at one end. The frame can be adjusted to hold blades of various lengths and

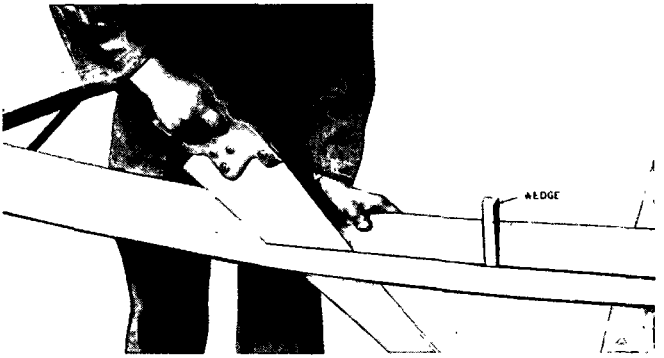
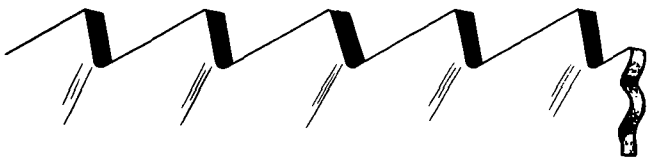


Figure 8. Ripsaw.

at various angles. The blades are of high grade tool steel with a "pitch" (the number of teeth per inch) of 18.

(*e*) *Large crosscut saws.*

1. *Two-man crosscut saw.* This saw (1, fig. 11) is a double handled saw used for heavy work such as felling trees, cutting large trees into logs, or sawing heavy bridge timbers. The blade is from 5 to 6½ feet in length. The saw is operated by two men, each man pulling the saw towards himself, being careful not to pinch the hands of the other man between the handle and the tree. As the saw is pulled, only guiding, not pushing by the other man, is required to prevent binding.

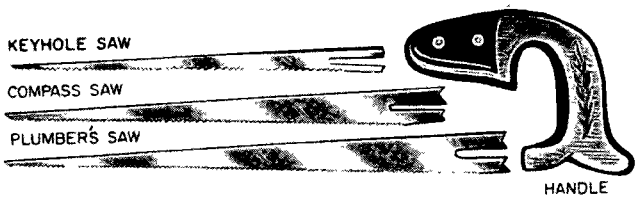


SIDE VIEW

TOP VIEW

Figure 8—Continued.

2. *One-man crosscut saw.* This saw (2, fig. 11) is shorter than the two-man saw, being 36 inches in length. It has two handles, one of which is shaped like that of the handsaw; the other is detachable and clamped to the top edge of the saw. This handle may be placed either at the



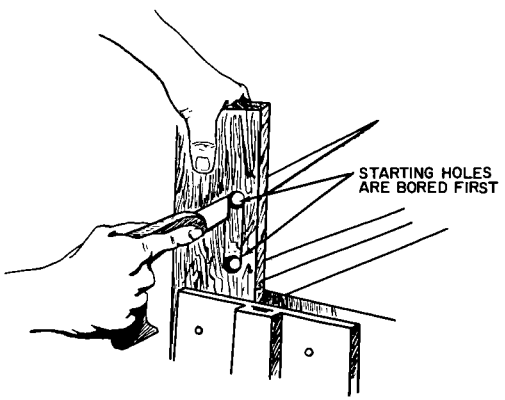


Figure 9. Nested saws.

heel, for one-man operation, or near the toe for two-man operation (2, fig. 11). The one-man saw is operated like the handsaw, using the detachable handle to aid in pulling the saw back. When used as a two-man saw, it is used as described in

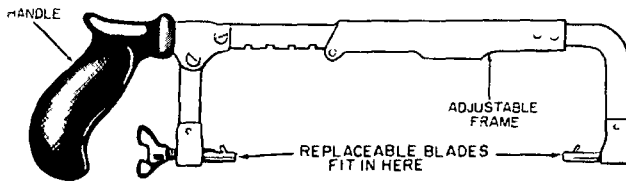


Figure 10. Hacksaw.

1 above. The care of handsaws is described in figure 12.

7. Driving Tools

a. Carpenter's Curved-Claw Nail Hammer. The carpenter's curved-claw nail hammer (fig. 13) is used for driving nails, wedges, and dowels. The "claw," which is at one end of the head, is a two-pronged arch used to pull nails out of wood.

b. Plastic Faced Hammer. The plastic faced hammer has a metal head on a wooden handle, with replaceable plastic faces which can be screwed onto the ends of the head. This hammer is designed for striking chisels and other tools which would be damaged by metal hammers.

c. Mason's Single-Faced Hammer. The mason's hammer is used for tapping rocks and bricks into place, and for chipping rocks and breaking bricks.

d. Blacksmith's Double-Face Sledge. The blacksmith's sledge (fig. 14) is a steel-headed heavy-duty tool. The weight of the sledge, 8 pounds, makes it ideal for driving heavy spikes

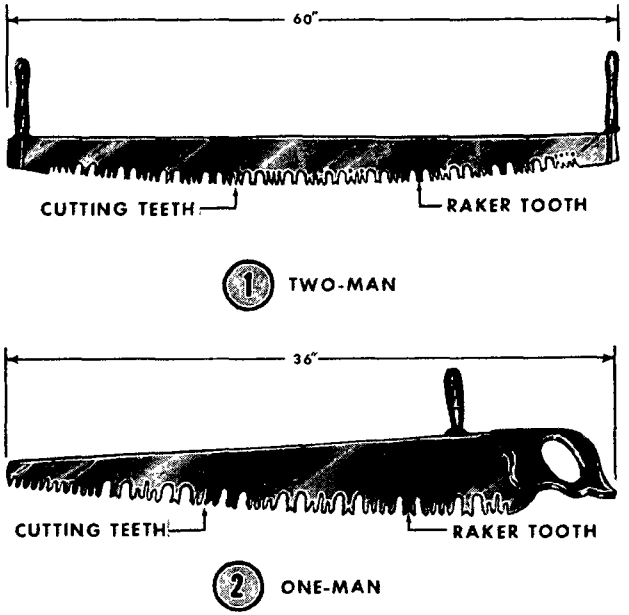


Figure 11. Large crosscut saws.

and drift bolts or for any other job which requires heavy blows.

e. Wooden Mallet. The wooden mallet, shown in figure 15, has a wooden head and two flat, circular faces reinforced by iron bands. The mallet is used for driving wooden stakes, smoothing out dents in sheet metal, or for turning thin metal edges without cutting the metal surface. The mallet is never used to drive spikes or any other metal objects with sharp heads.

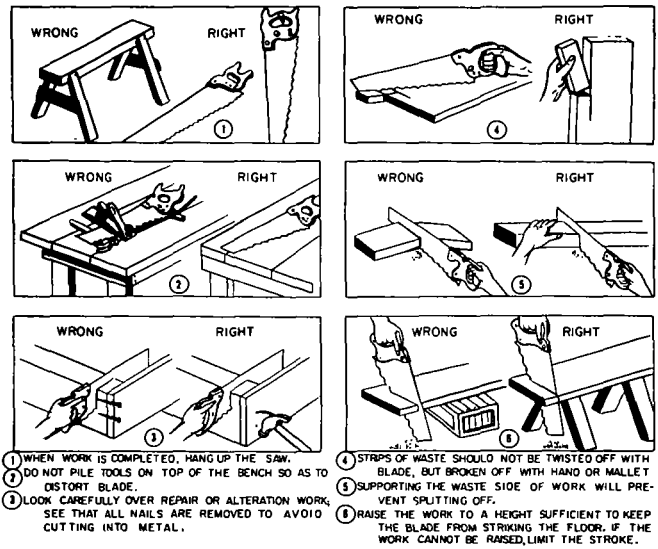


Figure 12. Care of handsaws.

8. Drilling and Boring Tools

a. Brace, Ratchet Type. The brace (fig. 16) is used to turn auger bits, expansive bits, countersinks, or screwdriver bits which are shown in figure 17. The brace consists of a head, a crank, a ratchet box, and a chuck. The head is fastened to the crank by a bearing which permits the crank to turn. The ratchet box controls whether the chuck turns or not when the crank is turned. Figure 18 illustrates the right and wrong way to bore through a board.

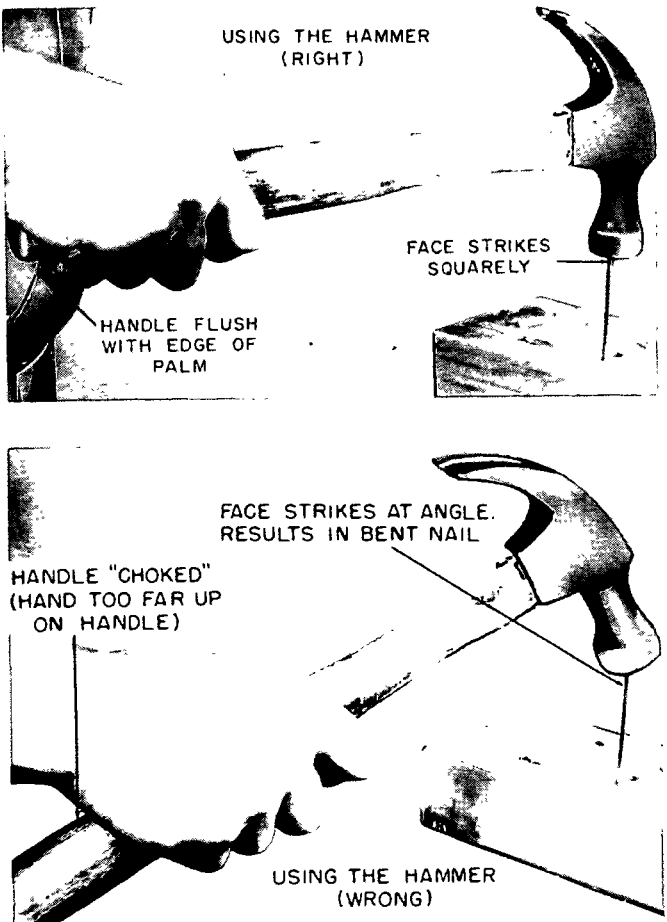


Figure 13. Using the carpenter's curved-claw hammer.

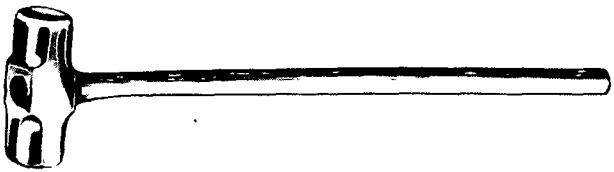


Figure 14. Blacksmith's double-faced sledge.

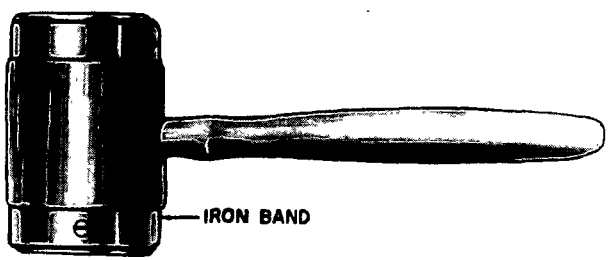


Figure 15. Wooden mallet.

b. Hand Drill. The hand drill (fig. 19) is used for drilling holes in metal or wood where power for an electric drill is not available.

c. Hollow Center Auger Bit. This auger bit (fig. 20) differs from others in that the shank does not continue through the center of the flute or twist. Instead, the flute is hollow so that the shavings may pass through the center. As the shavings are not crowded, it is possible to bore

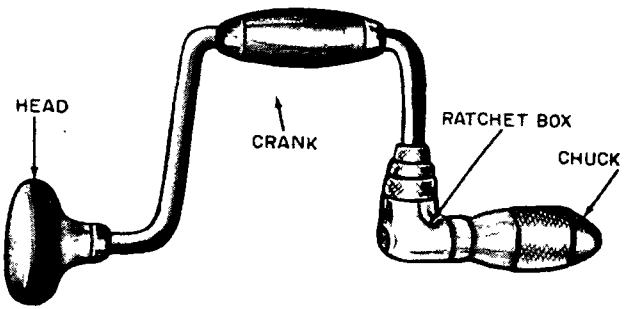


Figure 16. The brace.

deeper holes with this bit than with the regular auger bit. The top of the shank is square and pointed to fit a wooden handle.

d. Masonry Drill. The masonry drill (fig. 21) is used for drilling holes in concrete or stone. It is frequently called a star drill and is made from shafts of steel with a cutter at one end and a flat face on the other. The cutter edges are placed in position where the hole is to be drilled and the head of the drill is struck with a heavy hammer or sledge. The drill must be rotated after each blow to clear the chips from the hole and to keep the drill from binding. Always wear goggles when using the masonry drill.

9. Measuring and Layout Tools

a. Combination Square. The combination square (fig. 22) is a steel blade, 12 inches long, which is fitted to a metal head that can be clamped

(1) SCREWDRIVER BIT

(2) COUNTERSINK BIT

(3) EXPANSIVE BIT

(4) AUGER BIT

Figure 17. Bits used with brace.

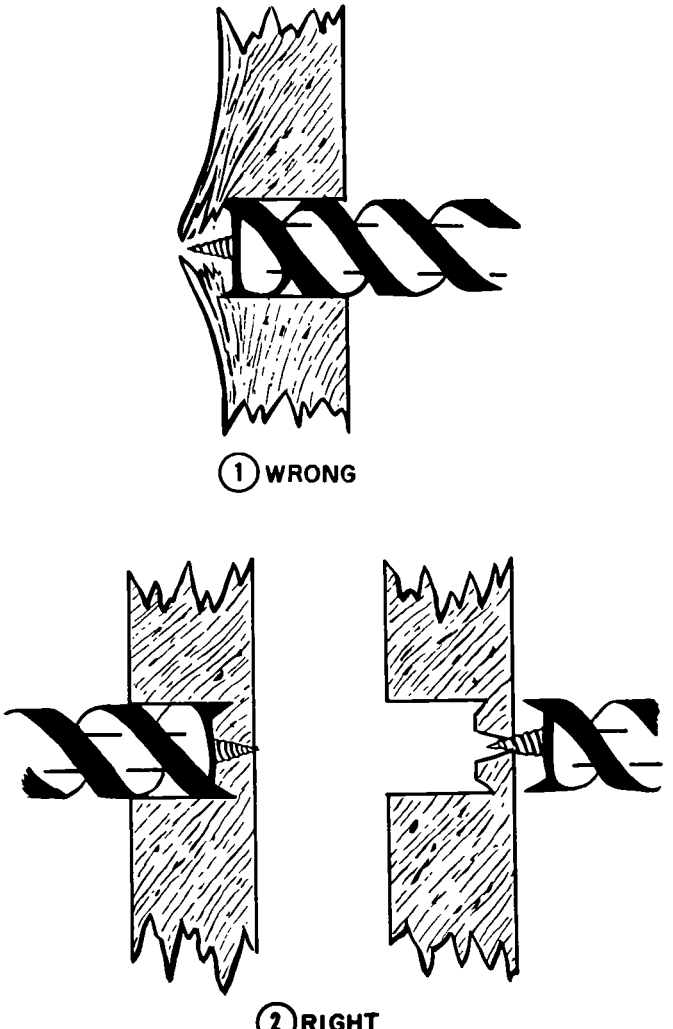


Figure 18. Right and wrong way to bore through a board.

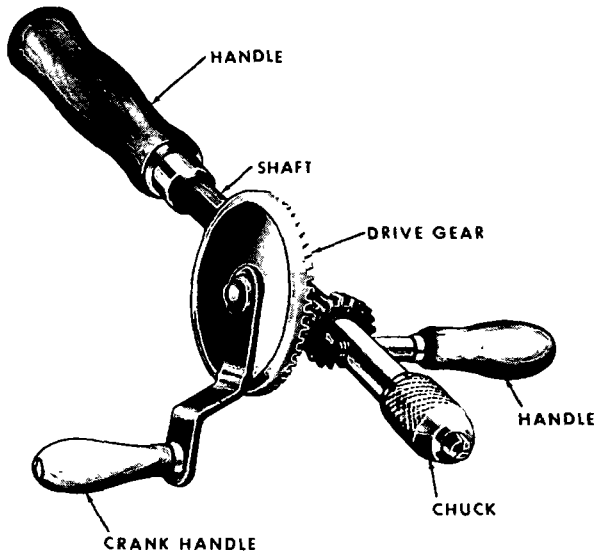


Figure 19. Hand drill.

at any desired position along the blade by use of a clamping screw.

b. Carpenter's Square. The carpenter's square (fig. 23) has two arms set at exact right angles with one another. The larger, which is 24 inches long, is called the *blade.* The smaller arm, called the *tongue,* is 16 inches long. In addition to the inch and fractional graduation, there are three tables on the square: the essex board measure, the brace measure table, and the rafter table. Figure

(1) HANDLE

(2)

Figure 20. Hollow center auger bit.

Figure 21. Masonry drill.

24 shows the method of using the carpenter's square.

c. Dividers. Dividers consist of a pair of pointed legs joined together at or near their tops. Dividers of the type furnished in the engineer carpenter's tool set are called wing dividers (1, fig. 25). The wing is an arc used to hold the legs at any desired distance apart by means of a set screw. Dividers are used to mark lengths into

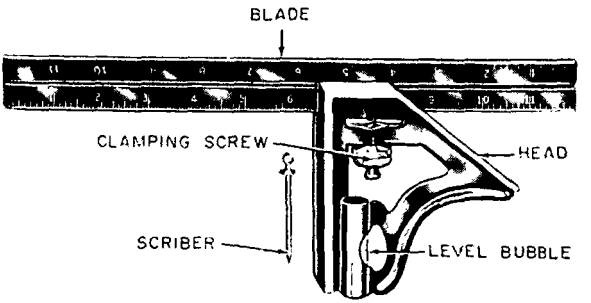


Figure 22. The combination square.

equal parts, to describe circles or arcs, or to transfer measurements from the work to the rule or from the rule to the work. Some of the uses are illustrated in 2, figure 25.

d. Line Level. The line level (fig. 26) consists of a bubble tube set into a metal case with a hook at each end to permit it to be suspended from a line or cord. The line level is particularly useful when the distance between two points to be checked is too long to permit the use of the carpenter's level.

e. Carpenter's Level. The carpenter's level (fig. 27) is a 24-inch wood block with true surface edges. There are two bubble tubes in it. The level is used to determine whether a surface is "level" or "plumb." "Plumb" means true vertical, or at right angles to "level." To check for plumb, set the long side of the carpenter's level

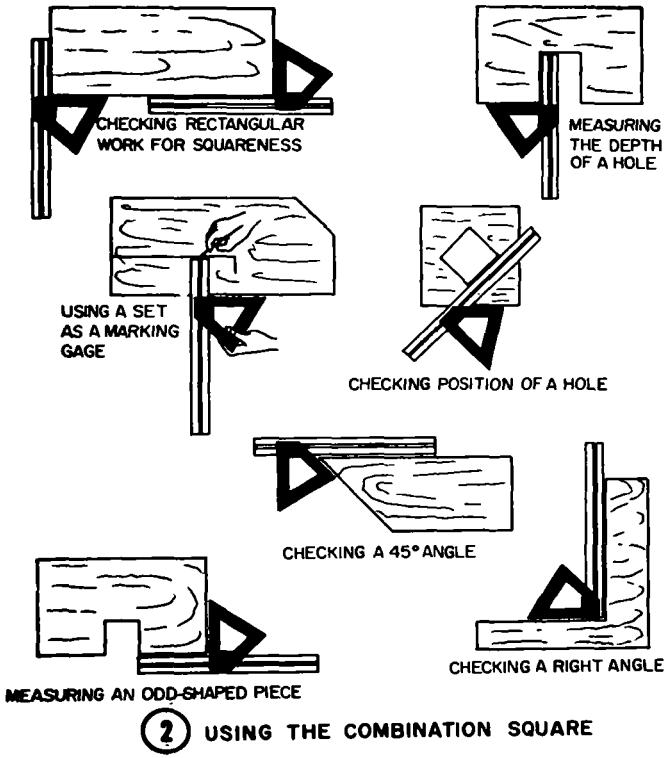


Figure 22—Continued.

against the upright to be tested and check the vertical bubble tube to see where the bubble comes to rest. If the upright is plumb, the bubble will rest in the center of the bubble tube.

10. Digging Tools

a. Post Hole Auger. The post hole auger (fig. 28) is designed to bore holes in the ground in

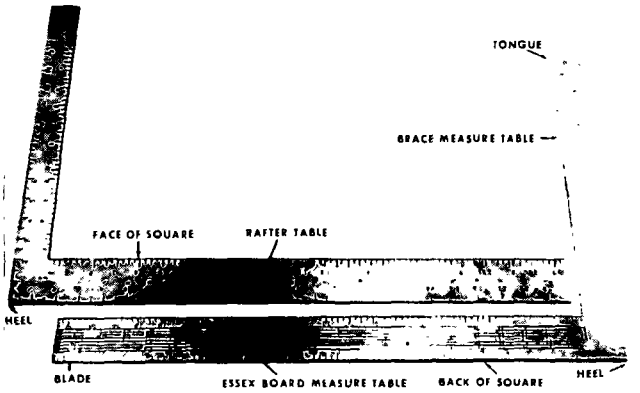


Figure 23. Carpenter's square.

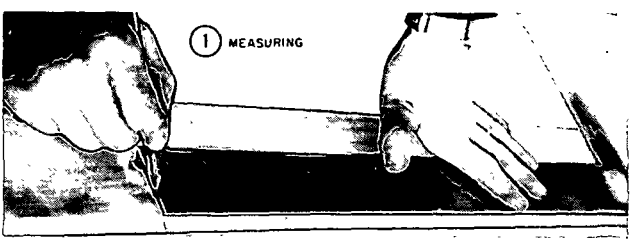


Figure 24. Using the carpenter's square.

order to install posts, poles, or explosive charges. The auger may be adjusted to bore holes from 8 to 14 inches in diameter and to 8 feet 3 inches deep. When using the auger break the crust of the earth or sod with a pick or shovel. Set the

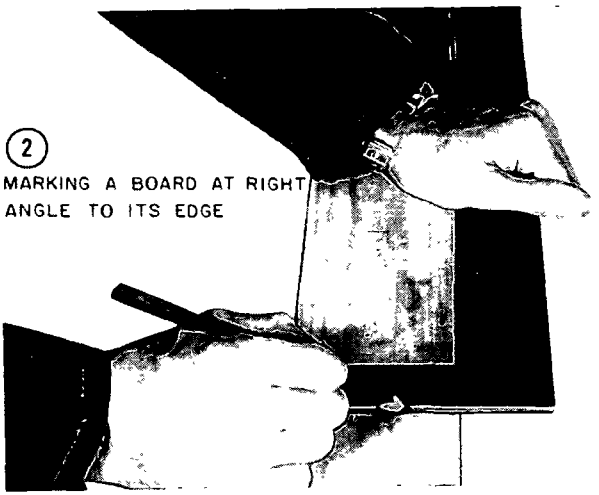


Figure 24—Continued.

auger into the hole, apply pressure on the top of the handle, while at the same time twisting the tool with the handle. Lift and empty the auger when it is full of earth.

b. Pick Mattock. The pick mattock (fig. 29) is used for digging in hard compacted soil. The pick end is used for breaking the surface of the earth. The wide blade is used for cutting roots underground, or for loosening clay in which there are no, or very few, rocks. A small amount of prying may be done with this tool; however, for heavy prying a bar should be used. Before swinging the pick, make sure no one is within reach of your swing.

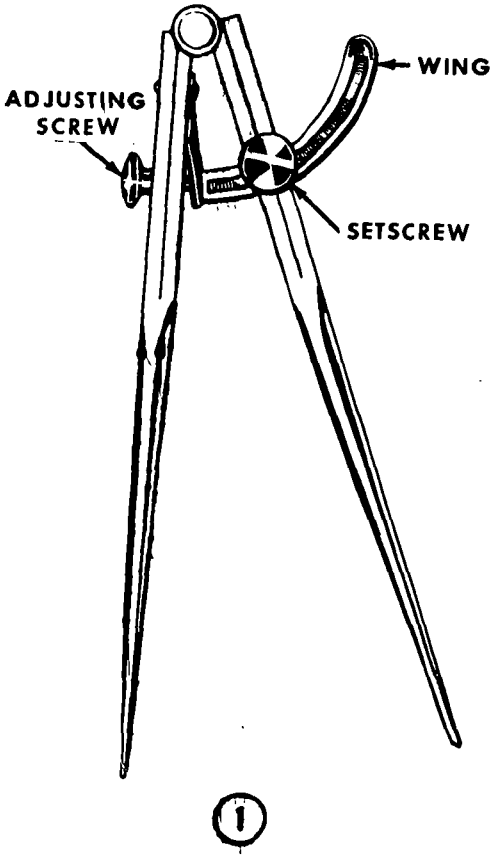


Figure 25. Wing dividers.

c. Shovels. There are many types of shovels for various uses. The two general types found in engineer sets are the D-handled round point and the long-handled round point shown in figure 30.

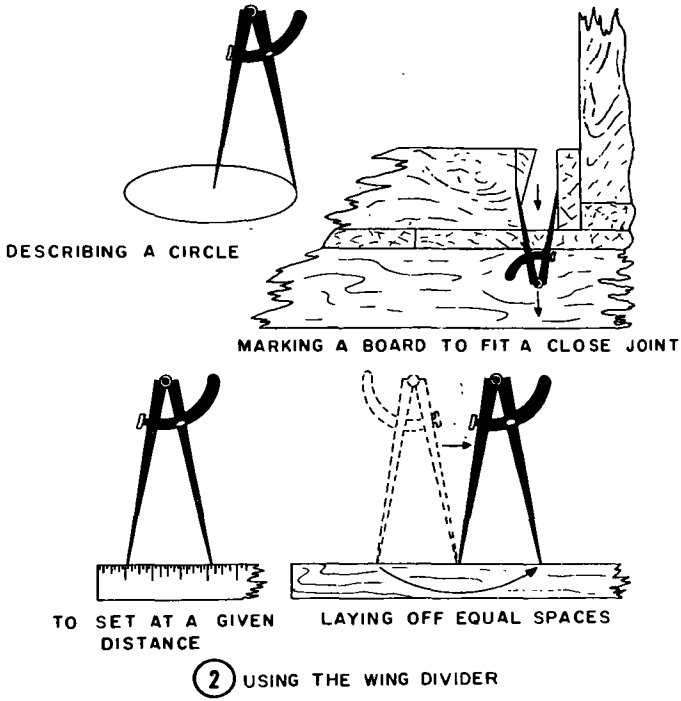


Figure 25—Continued.

(1) The D-handled shovel is designed for light work or for digging in cramped spaces. It has a short handle (about 3 feet in length) at the top of which is a hand grip.

(2) The long-handled shovel is the best for most kinds of heavy work, such as digging trenches or any other digging in which there is sufficient room to swing

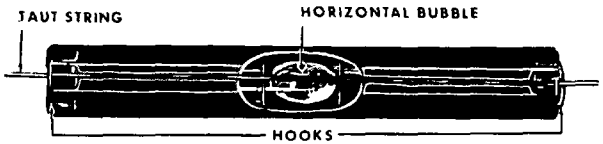


Figure 26. Line level.

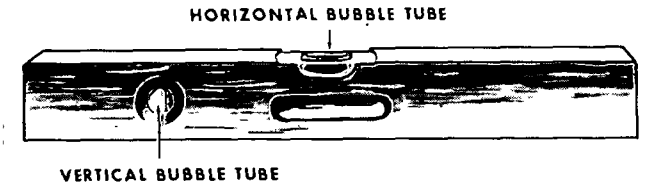


Figure 27. Carpenter's level.

it. This shovel has no hand grip; instead, it has a handle about 5 feet long.

d. Miner's Spoon. The miner's spoon (fig. 31) is a slender metal rod with ends forged into small pans at right angles to the rod. These pans or bowls are $1\frac{5}{16}$ inches in diameter. The miner's spoon is used for lifting material out of small diameter deep holes, such as those made by the rock drill.

11. Chopping Tools

a. Single Bit Ax. The single bit ax (fig. 32) is a chopping tool consisting of a steel head and

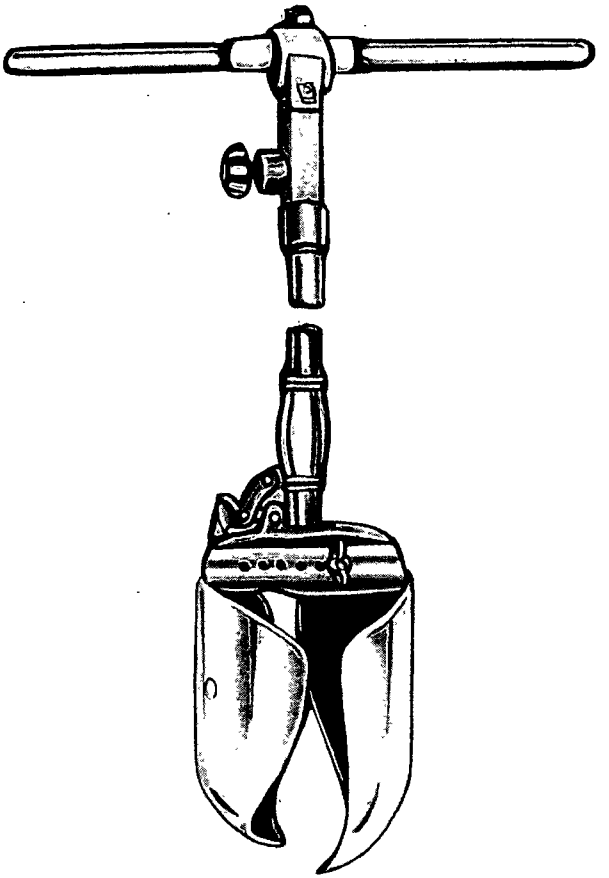


Figure 28. Post hole auger.

wooden handle. The ax is used to fell trees, cut logs into convenient lengths, and to split and cut wood. Although not primarily designed for such,

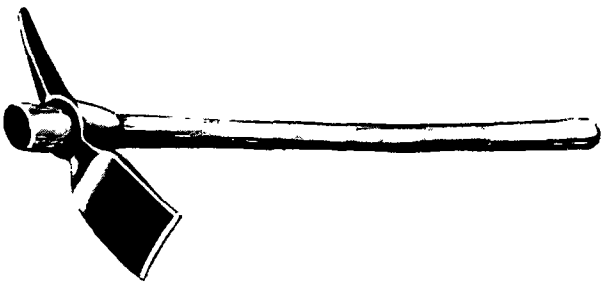


Figure 29. Pick mattock.

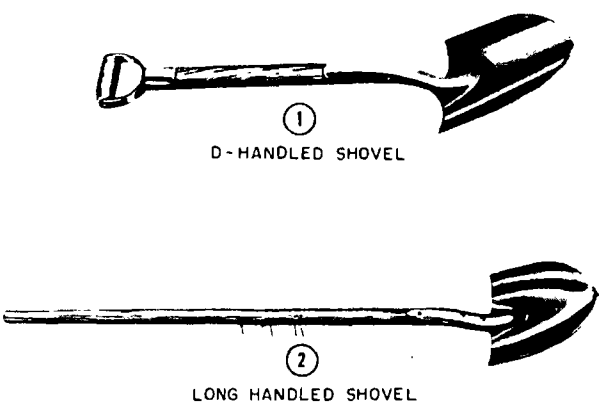


Figure 30. Types of shovels.

it may be used for driving wooden stakes with the flat face part of the head. Figure 33 shows the correct method for using the ax for chopping.

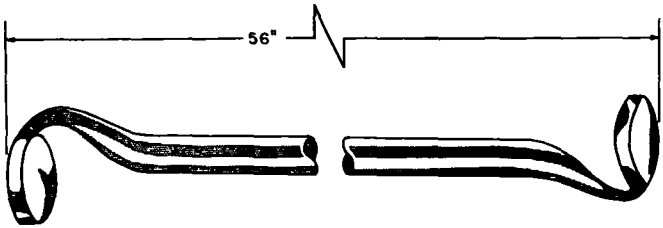


Figure 31. The miner's spoon.

Figure 32. The single bit ax.

b. Half-hatchet. The half-hatchet (fig. 34) is a combination chopping and driving tool. It has a wooden handle and a steel head. The head has a hammer face, an eye, and a blade. The blade has a notch for pulling nails less than 8d in size. The hatchet is most effectively used when chopping with the grain of the wood.

c. Adz. The adz (fig. 35) consists of a hardened steel head with a curved blade at one end 3½ inches to 4½ inches wide and a curved wooden handle to give balance and the proper

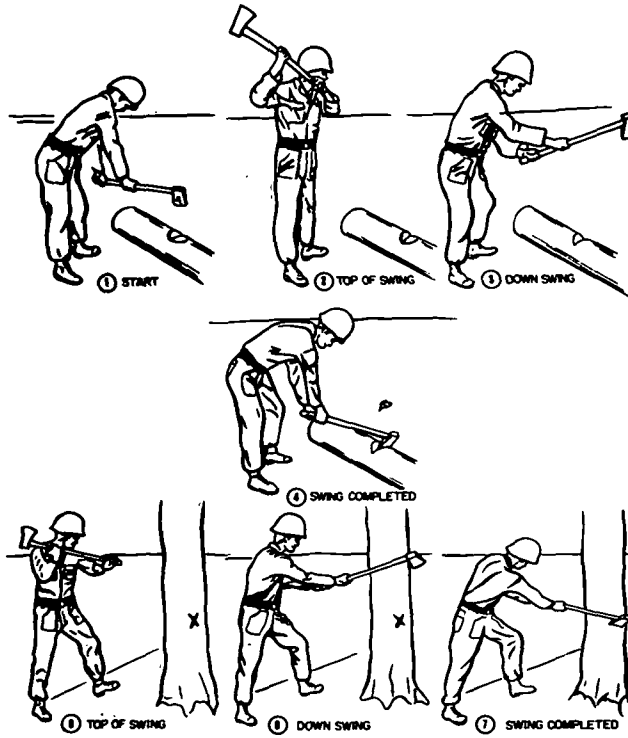


Figure 33. Using the single bit ax.

angle for cutting. The adz is used for cutting, shaping, and smoothing lumber or logs when a large amount of wood is to be removed. To use the adz the timber to be worked should be straddled. The adz should be swung downward and toward the body using short chopping strokes.

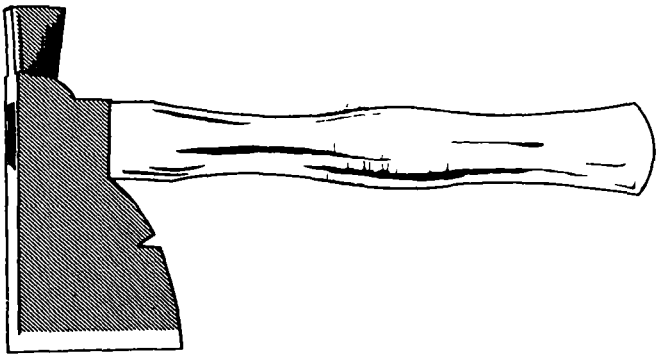


Figure 34. Half-hatchet.

12. Miscellaneous Tools

a. Timber Carrier. The timber carrier (fig. 36) consists of a pair of large hooks with sharply pointed ends, hung by pivots on a 4-foot handle. Two or more carriers are placed along the timber to be carried. The points of the hooks are driven securely into the timber, either by sharp jerks on the handles, or by tapping the points into place. With one man at each handle, the timber is lifted and carried away as shown in figure 37.

b. Peavy. The peavy (fig. 38) is a heavy pole set into a steel socket at the end of which is a sharp spiked point. Attached to the side of the socket is a curved hook hinged to the socket. The peavy is used for rolling, turning, or carrying logs or other timbers as shown in figure 39.

Figure 35. The adz.

c. Machete. The machete (fig. 40) is a long (18 inches) knife. The blade is widest and heaviest at the point. The handle is shaped to fit the hand and has a slight projection at the end to prevent the machete from slipping during use. The machete is particularly valuable for cutting tall grass, vines, and small brush (see fig. 41). Make sure you have room to swing the machete

Figure 35—Continued.

when using it. Branches or brush may cause the strokes to be deflected. Make sure no one is within reach of your swing.

d. Timber Wedge. The timber wedge, shown in figure 42, is a steel tool used for splitting tim-

SWING COMPLETED

Figure 35—Continued.

ber. It looks very much like a slender ax head except that it has no eye. It weighs 5 pounds. Wedges are usually used in pairs. After the split has been started with an ax, one wedge is driven into the split with a sledge, forcing the timber fibers apart. This wedge is left in place to hold the fibers apart while another is driven into the

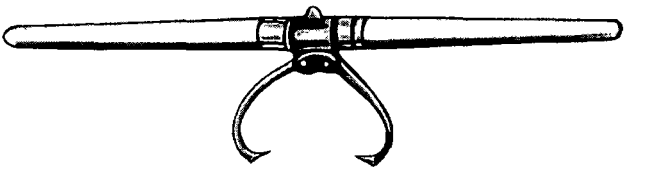


Figure 36. Timber carrier.

Figure 37. Using the timber carrier.

split further along the log. The wedges are then driven deeper alternately until the log falls apart.

e. Railroad Clawbar. The railroad clawbar (1, fig. 43) is a heavy, 4-foot long metal bar, one end of which is pointed; the other end has a large claw set at an angle to the bar. The railroad

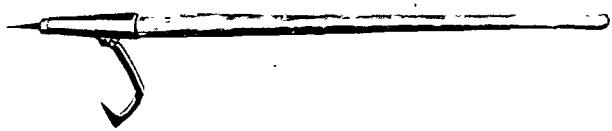


Figure 38. Peavy.

Figure 39. Rolling a log with peavies.

clawbar is used primarily for pulling railroad spikes from ties.

f. Pinchbar. The pinchbar (2, fig. 43) is a steel rod, usually of ¾-inch material, with one

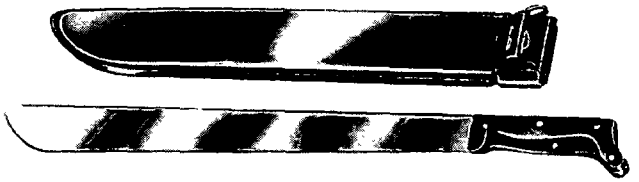


Figure 40. Machete and sheath.

end pointed and the other end wedged shape. The pinchbar is used for prying, as in opening boxes and crates, and loosening boards.

g. Wrecking Bar. Wrecking bars may be either straight, claw and pinchpoint, or goose-necked as in 3, figure 43. In either case, the wrecking bar has a claw at one end. The other end is wedged shaped and bent at a slight angle to the bar. The wrecking bar is used to remove nails or spikes from boards and for prying boards loose (fig. 44).

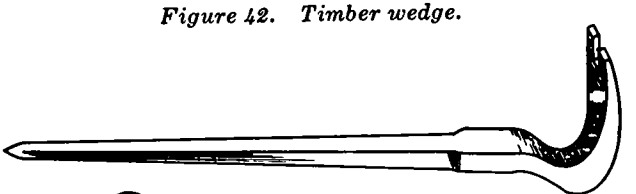
h. Crowbar. The crowbar is a heavy steel bar about 5 feet in length (4, fig. 43). It is used as a lever for moving heavy objects short distances. It is also used for prying loose heavy boulders and for breaking up hard earth formations in digging.

i. Bolt Cutters. Bolt cutters (fig. 45) are large shears with very short blades and long handles. They are designed to cut mild steel rods up to $\frac{3}{8}$

Figure 41. Using the machete.

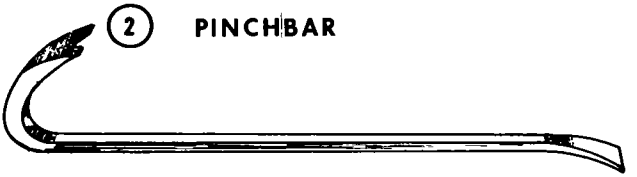
inches in diameter. The material to be cut must be kept as far back in the jaws as possible. Make sure that you keep your fingers out of the jaws and hinges.

Figure 42. Timber wedge.



1 RAILROAD CLAWBAR

2 PINCHBAR



3 GOOSENECK WRECKING BAR

4 CROWBAR

Figure 43. Types of bars.

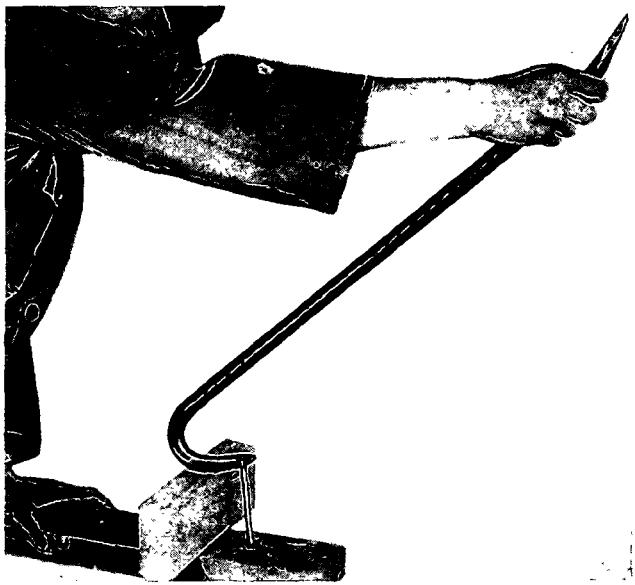


Figure 44. Pulling a spike with the gooseneck wrecking bar.

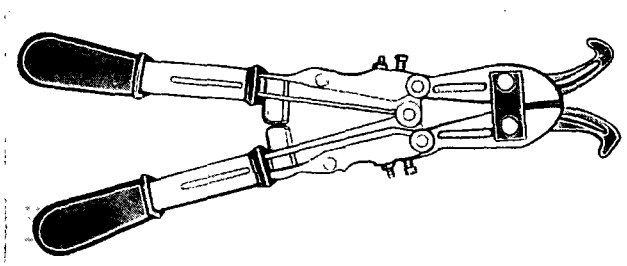


Figure 45. Bolt cutters.

Section II. Power Tools

13. Pneumatic Tools

Pneumatic tools are common to both combat and construction engineers. The power required to operate these tools is supplied by air compressors. The following tools are found in the pneumatic tool set and are shown in figure 46.

a. Paving Breaker. Used to cut asphalt or concrete pavement and to demolish concrete foundations, retaining walls, culverts, and floors. It may be used also to drive sheet piling, by removing the moilpoint and substituting the sheet pile driving attachment.

b. Rock Drill. Used in rock excavation and quarry work to drill holes for blasting charges.

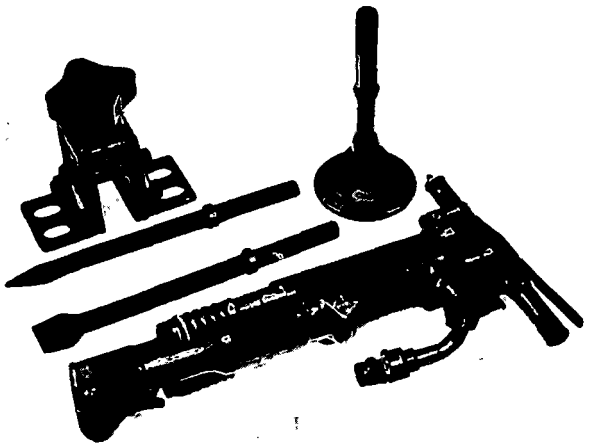
c. Clay Digger. Used to facilitate hand digging or machine excavation in stiff clay, hard sand, or gravel; also used to cut up asphalt cement.

d. Nail Driver. Used to drive large nails, spikes, and driftpins in the construction of bridges and buildings.

e. Backfill Tamper. Used to compact earth backfill around culverts and fill material for crater repair and under road patches.

f. Portable Steel Drill. Used to drill holes into steel for structural steel construction, equipment, and other items.

g. Portable Woodboring Drill. Used to bore holes in wood for demolition charges and for construction of bridges and buildings.



Paving breaker

Figure 46. Pneumatic tools.

h. Circular Woodworking Saw. Used for crosscutting or ripsawing lumber or planking for construction purposes as needed.

i. Portable Timber Chain Saw. Used in clearing timber and in support of construction tasks.

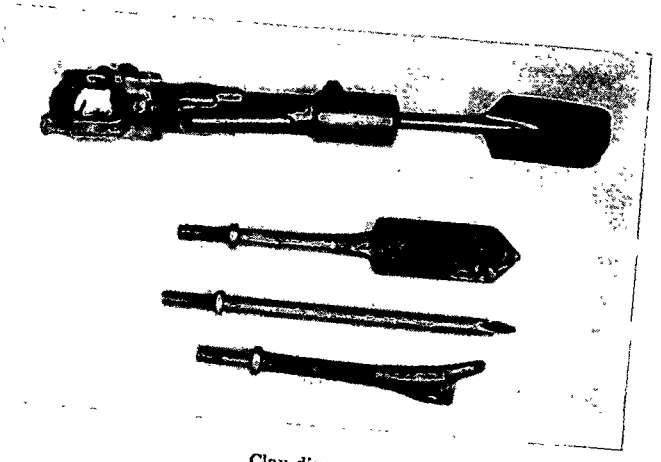
j. Concrete Vibrator. The primary purpose of the vibrator is to consolidate concrete by eliminating voids.

k. Pneumatic Grinder. Used to sharpen and maintain tools, notch out structural steel, and rough polish surface irregularities.

l. Sump Pump. Used to pump water out of excavations.

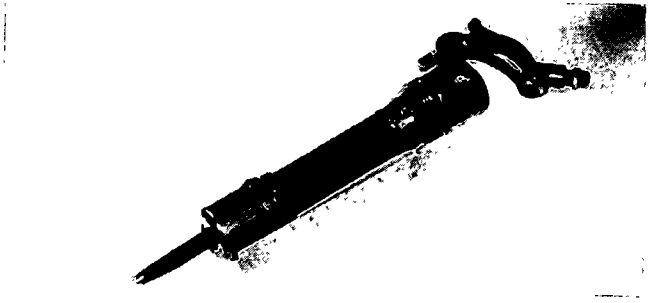
Rock drill

Figure 46—Continued.

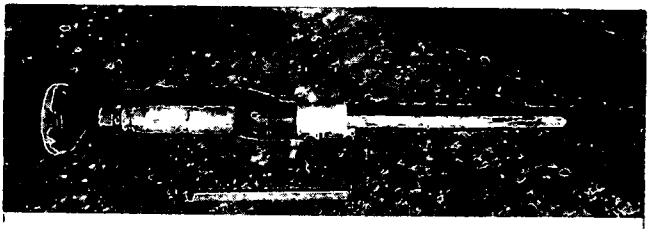


Clay digger

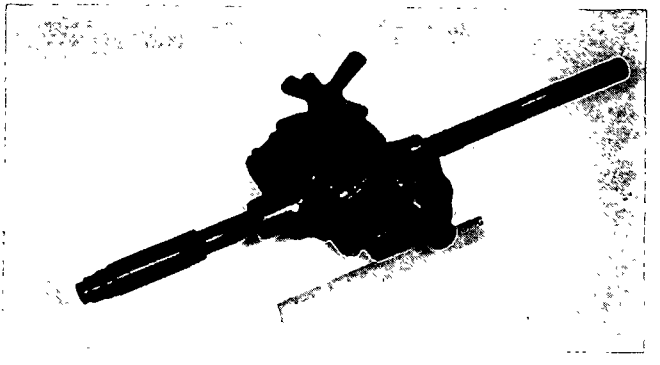
Figure 46—Continued.



Nail driver

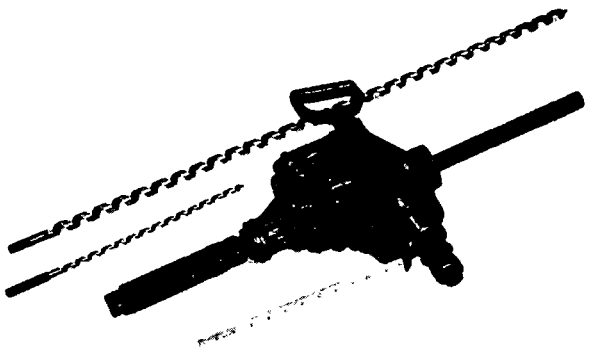


Backfill tamper

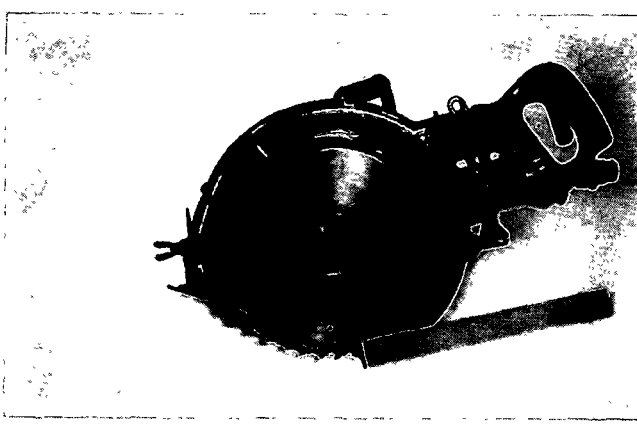


Steel drill

Figure 46—Continued.

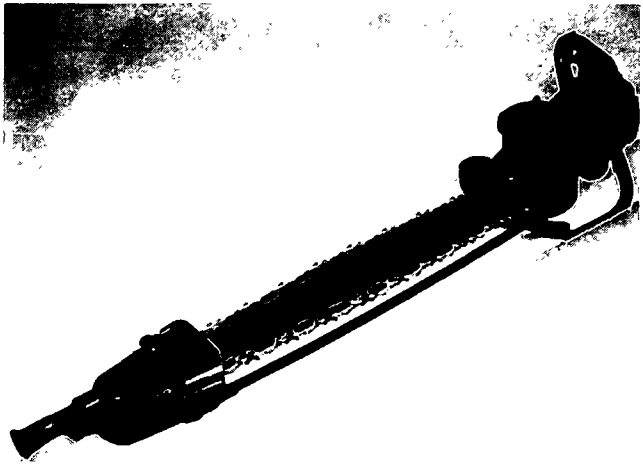


Woodboring drill



Circular woodworking saw

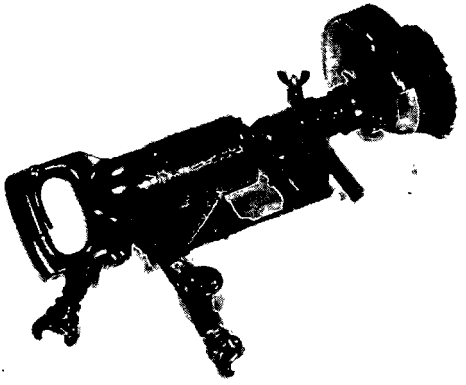
Figure 46—Continued.



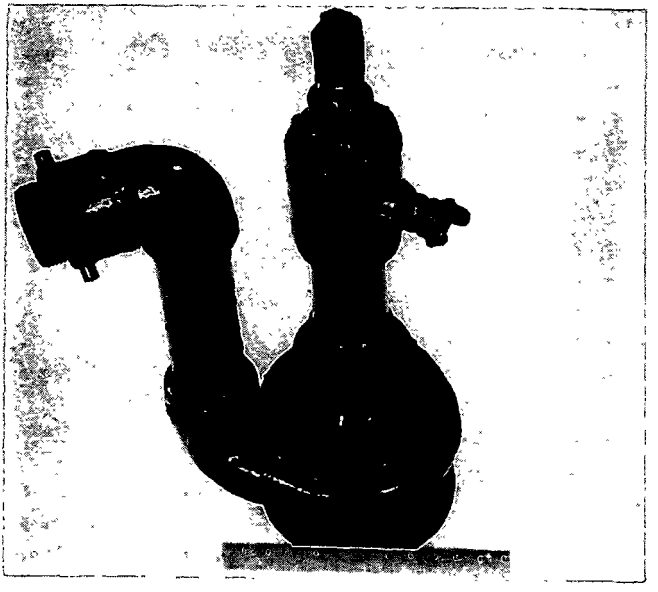
Timber chain saw

Concrete vibrator

Figure 46—Continued.



Penumatic Grinder



Sump pump

Figure 46—Continued.

14. Gasoline Portable Chain Saw

a. Use. The gasoline portable chain saw (fig. 47) is a portable two-man or one-man tool for felling trees, sawing logs, and other similar operations for which two-man crosscut saws are used. The procedure for felling trees with a chain saw is much the same as when handtools are employed.

b. Operating Safety Precautions.

(1) Do not start engine with clutch engaged.

(2) Do not operate engine in a closed room.

(3) Do not transport saw from tree to tree with chain running.

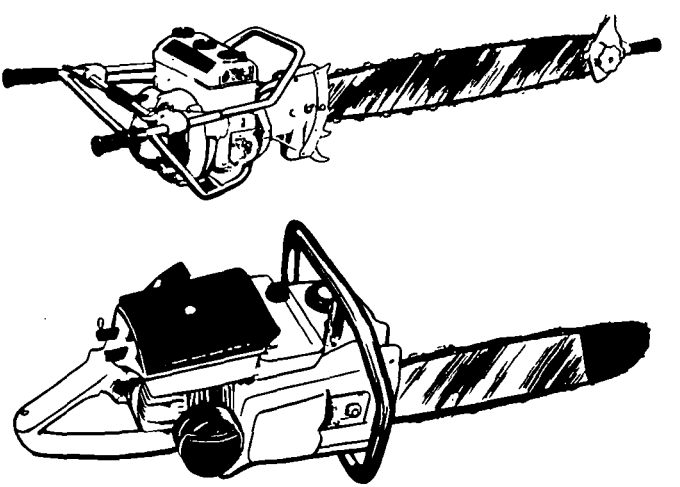


Figure 47. Gasoline powered chain saws.

(4) Do not operate unit with fan screen removed. (Fan screen prevents injury to operator and keeps out leaves, etc.)

(5) Do not wear loose, flapping clothing or ragged gloves.

(6) Do not wear slippery foot gear. (Good footing is important to safety.)

CHAPTER 3

ELEMENTARY RIGGING

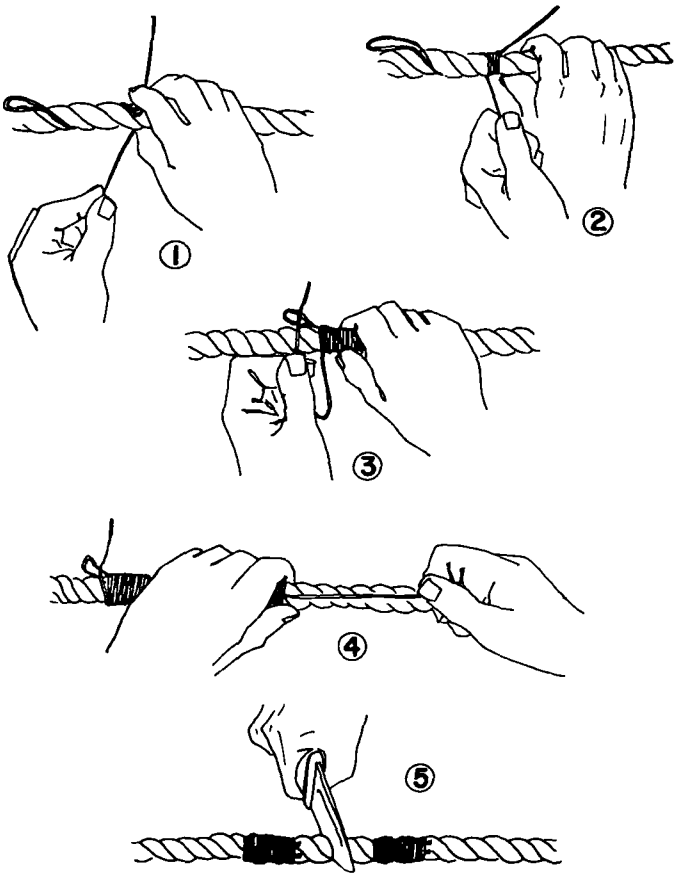
15. Introduction

This chapter sets forth the basic principles and techniques for the selection, layout, erection, and operation of lifting and moving devices. It includes basic instruction on knots, lashings, splices, and tackle systems. For detailed information on rigging, refer to TM 5–725.

16. Care and Use of Fiber Rope

The useful life of fiber rope will be shortened considerably and its strength decreased rapidly by improper storage, exposure to dampness, sand, oil, or damage to the strands. Loose ends of a fiber rope should be tied in a knot or the ends whipped to prevent untwisting or unlaying (fig. 48). Wherever possible, use knots that can be untied easily to eliminate the necessity for cutting the rope. When rope becomes unsafe to use, it should be destroyed or cut up in pieces short enough to prevent its use in hoisting. The short pieces can be employed for miscellaneous use but should not be used to suspend loads as in hoisting.

The card wrapping at the rope end to prevent untwisting is called **whipping**. Put on whipping before cutting rope. Tight whipping stays in place and permits threading rope through blocks and other openings.



Install whipping on both sides of cut.

Figure 48. Whipping the end of a rope.

17. Coiling and Uncoiling

New rope is coiled into bales usually containing 1,200 feet. To uncoil the rope, cut away the binding on the coil and pull the end of the rope up through the center of the coil. Uncoil rope from the center of the coil in the opposite direction of the lay. Lay refers to the direction of winding of the strands in the rope. Right-hand laid rope is properly coiled clockwise and uncoiled counterclockwise.

18. Definitions

a. Fundamental Elements.

(1) *Running end.* The running end is the free or working end of a rope.

(2) *Standing part.* The standing part is the balance of the rope excluding the running end.

(3) *Bight.* A bight is a bend or U-shaped curve in a rope.

(4) *Loop.* A loop is a fold or doubling of a rope through which another rope can be passed. A temporary loop is made by a knot or a hitch. A permanent loop is made by a splice or some other permanent means.

(5) *Turn.* A turn is the same as a loop, but usually describes the placing of a rope around an object such as a post, rail, or ring with the running end continuing in the direction opposite to the standing part.

(6) *Round turn.* A round turn is the same as a turn, with the running end leaving the encircled object in the same general direction as the standing part.

(7) *Overhand turn or loop.* An overhand turn or loop is made when the running end passes over the standing part.

(8) *Underhand turn or loop.* An underhand turn or loop is made when the running end passes under the standing part.

b. Figure 49 illustrates each of the above.

19. Knots and Their Uses

There are many different types of knots and each performs a certain function in rigging. Figures 50 through 68 illustrate the proper method of tying the basic knots and describe their uses.

20. Lashings

Lashing is the wrapping of rope around two or more pieces of timber (usually referred to as spars or legs) to fasten them together. Figure 69 shows the two methods of lashing three spars to form a tripod. Figure 84 shows the detail for shear lashing. Square lashings are used to join a vertical member to a spar. Block lashings are used to join a block or swivel to an object.

21. Splices

Splices are used to join fiber rope or wire rope. The splices are as strong as the rope or cable itself. There are four general types of splices in

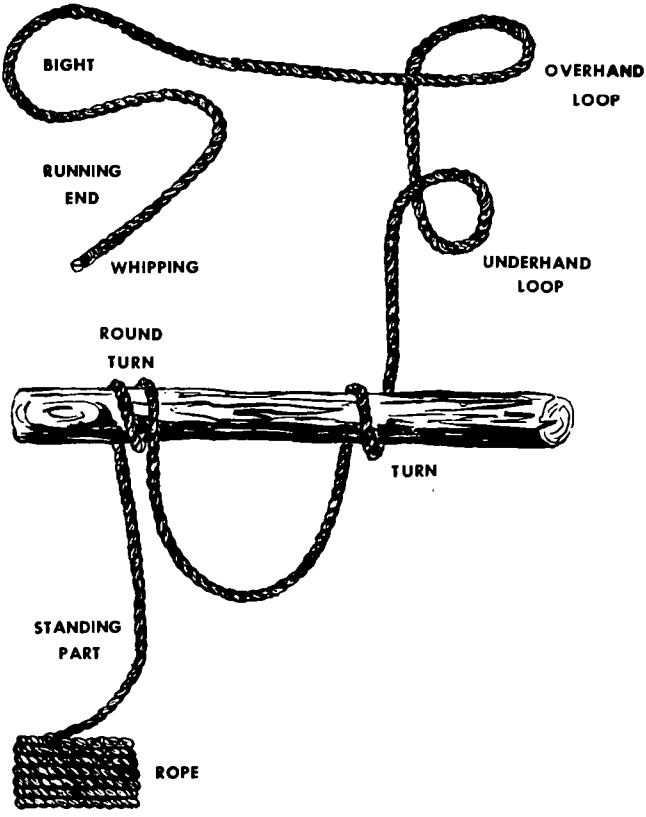


Figure 49. Elements of rope used in rigging.

fiber rope—long, back, short, and eye splices; all four types are similar. If one type of splice is mastered, all splices can be easily accomplished. No special tools are necessary for splicing fiber rope, but it will be found helpful to have a marline-spike available. All splices consist of three principal steps: unlaying the strands of the rope;

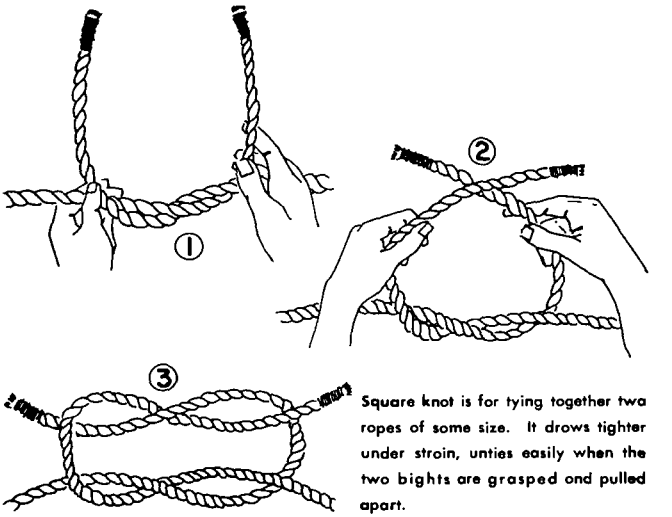


Figure 50. Square knot.

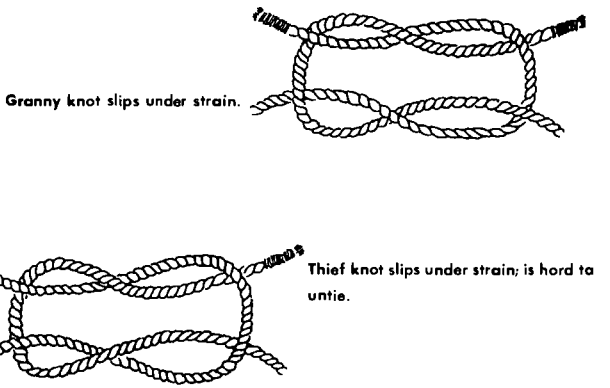


Figure 51. Granny and thief knots.

placing the rope ends together; and interweaving the strands and tucking them into the rope. Figures 70 and 71 illustrate the correct method for making the short splice and the eye or side splice.

22. Care and Use of Wire Rope

Correct handling of wire rope at all times is essential to maximum service. The following precautions should be observed:

a. Reels of wire rope should not be dropped. Weight of rope may break reel, permitting rope to become kinked.

b. Prying with bars should be done on flanges of reel, not on rope.

c. Wire rope should be stored in a dry place and away from corrosive fumes. Outside layer of reel or coil should be protected by a layer of lubricant. Wire in use should be well lubricated.

d. Newly installed wire rope should be worked for a while without load to enable the rope to adjust itself to working conditions.

The **OVERHAND KNOT** is used to prevent the end of the rope from untwisting, to form o knot at the end of o rope, or os part of another knot.

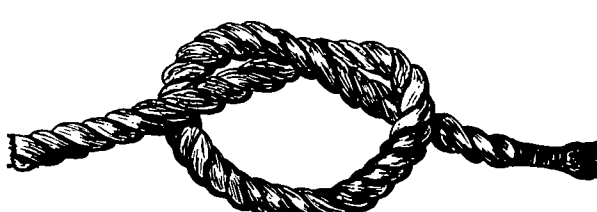
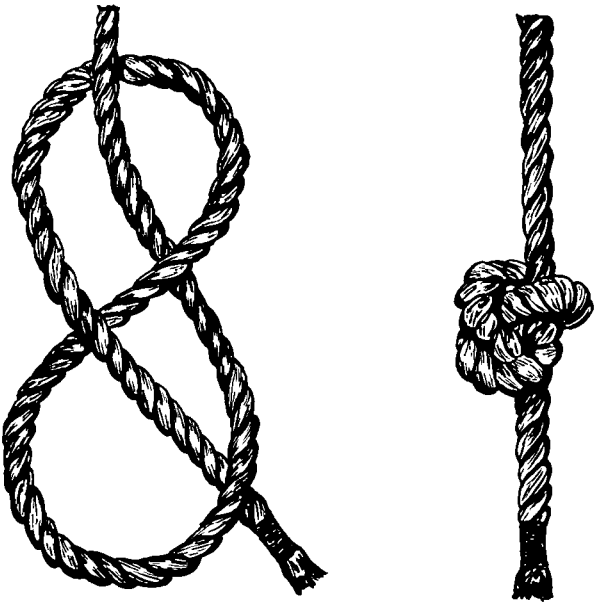


Figure 52. Overhand knot.



The **FIGURE EIGHT KNOT** is used in the end of a rope to prevent it from slipping through a fastening or loop in another rope.

Figure 53. Figure eight knot.

e. To avoid sharp kinks, all loops in slack rope should be straightened before load is applied. To remove a kink, wire rope must be bent back and reversed to direction in which kink was formed. A kink cannot be straightened by pulling the rope taut; this merely unlays the rope.

f. Loads must not be applied suddenly. This puts excessive strain on rope.

g. Avoid using wire rope on sheaves or drums which are too small, and avoid reverse bends or

sudden changes in direction of pull. **Either of** these conditions causes severe strain **and broken** wires in strands and weakens rope.

h. To avoid accidents, every reasonable effort should be made to stand clear of any wire rope under tension.

i. Work gloves should be worn at all times when handling wire rope.

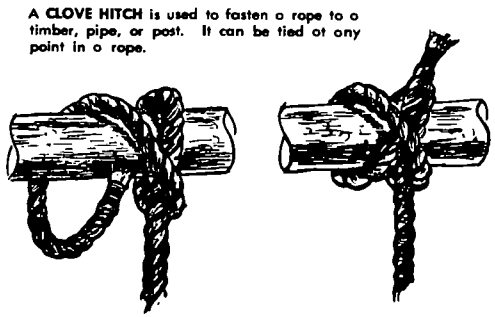


Figure 54. Clove hitch (end of rope).

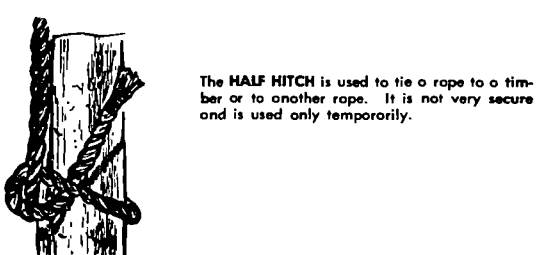


Figure 55. Half hitch.

The **TIMBER HITCH** is used for moving heavy timbers or poles. To keep the load straight when moving, one or more half hitches can be used in conjunction with the timber hitch.

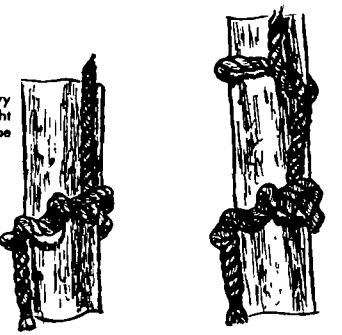
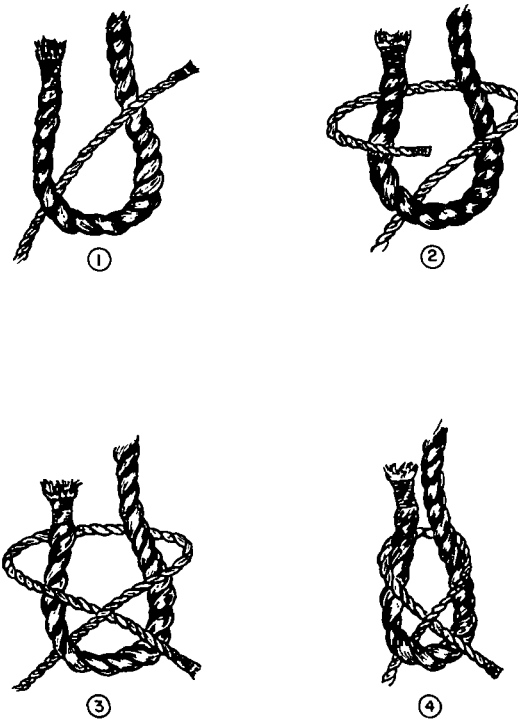


Figure 56. Timber hitch and half hitch (end of rope).

23. Slings

Slings may be made of fiber rope, wire rope, or chain. The sling for lifting a given load may be an endless sling, a single sling, or several single slings used together to form a combination sling. Fiber rope makes good sling material because of its flexibility, but is more easily damaged by sharp edges on the material hoisted than wire rope or chain slings. Wire rope is usually used for slings because of its strength combined with flexibility. Chain slings are used in special circumstances where sharp edges of metal would cut or damage wire rope slings.

a. Endless Slings. Endless slings are made by splicing the ends of a piece of wire rope or fiber rope together, or by the insertion of a cold sheet link in a chain. Cold sheet links should be welded after insertion in the chain. Endless slings are simple to handle and may be used in several different ways to lift loads (fig. 72).



The **SINGLE SHEET BEND** (sometimes called a weaver's knot) is limited to tying two dry ropes of unequal size. This knot draws tight under load but will loosen or slip when the lines are slackened.

Figure 57. Single sheet bend.

b. Single Slings. A single sling may be made of wire rope, fiber rope, or chain. Each end of the sling (fig. 73) is made up into an eye, or has a hook attached. The methods of using single slings are shown in figure 74.

A **CATSPAW** is used for fastening an endless sling to a hook or it may be made at the end of a rope for fastening the rope to a hook.

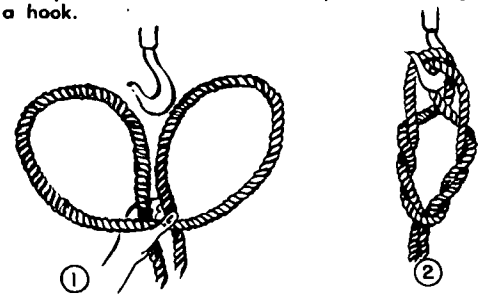


Figure 58. Catspaws.

The **RUNNING BOWLINE** is a multipurpose knot. It provides a sling of the choker type at the end of a single line and is used generally in rigging for this purpose.

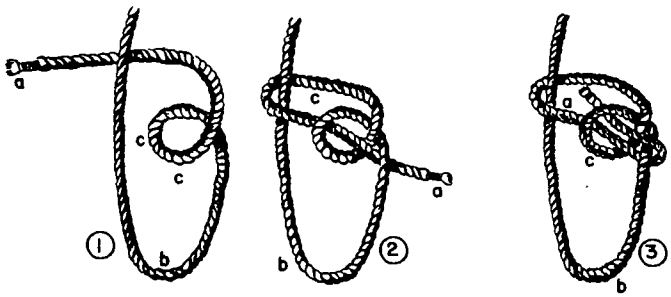


Figure 59. Running bowline.

A **ROLLING OR MAGNUS HITCH** is a safety knot designed to make a running end fast to a suspension line with a nonslip grip. Knot can be released by hand pressure bending the knot downward.

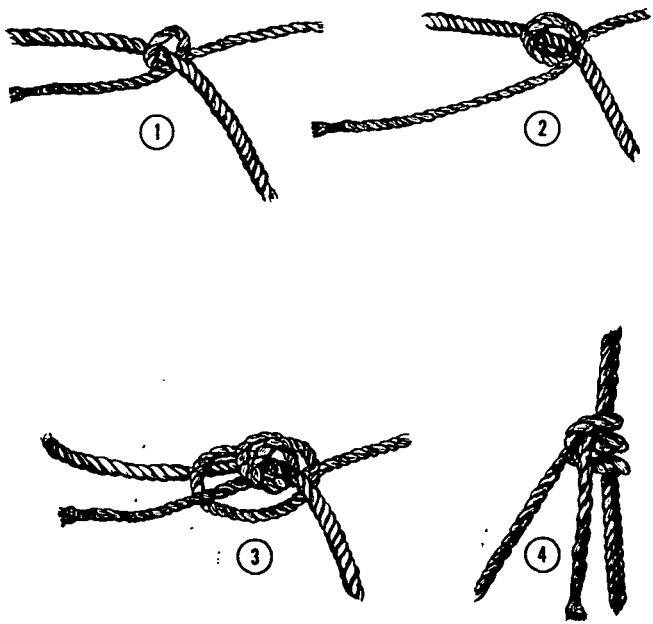


Figure 60. Rolling or magnus hitch.

The **BOWLINE ON A BIGHT** is used to form a loop in a rope other than at the end. The knot is easily untied and will not slip.

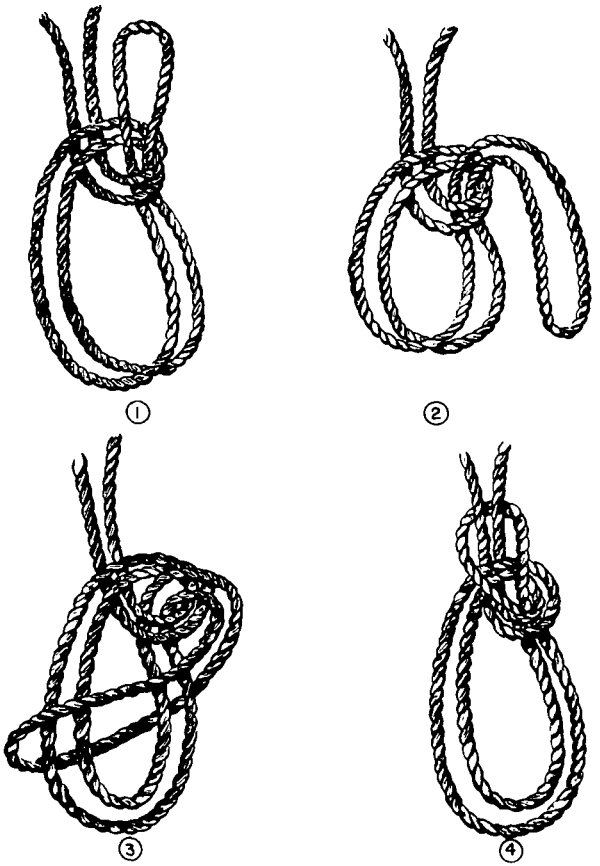


Figure 61. Bowline on a bight.

The **SPANISH BOWLINE** can be tied at any point in a rope. This knot is used generally in rescue operations or to give a twofold grip on a round object.

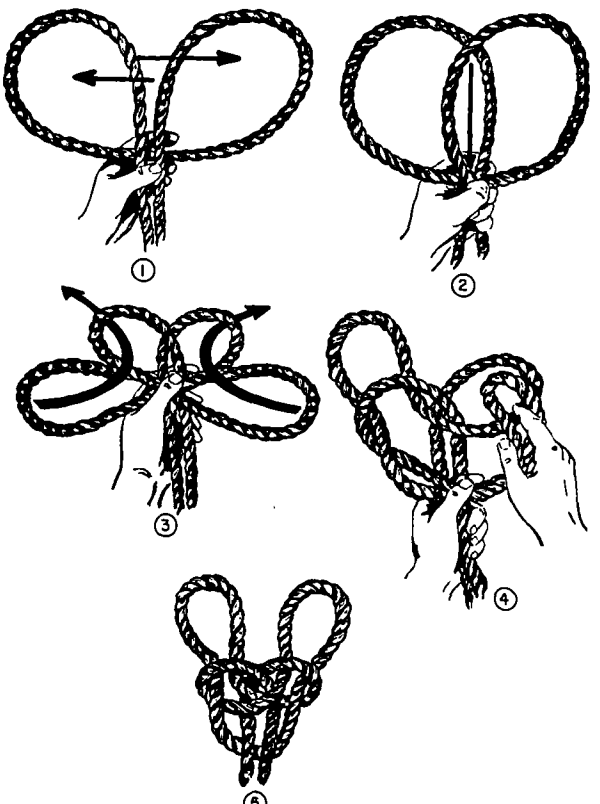


Figure 62. Spanish bowline.

The **FRENCH BOWLINE** is often used as a sling to transport personnel. When used in this manner, one loop is used as a seat and the other loop is placed around the body under the arms.

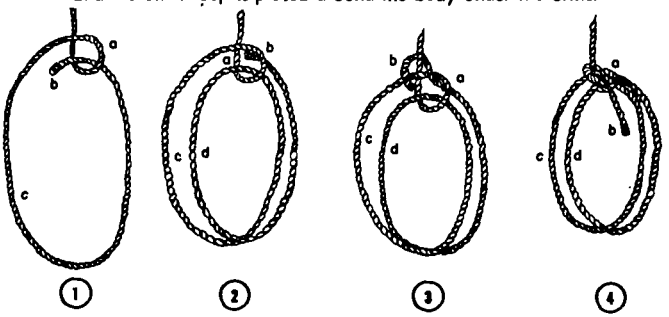


Figure 63. French bowline.

The **BECKET HITCH** is used for fastening a rope to the becket of a block or a ring.

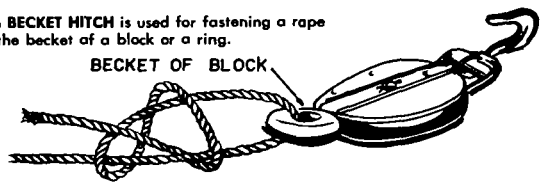


Figure 64. Becket hitch.

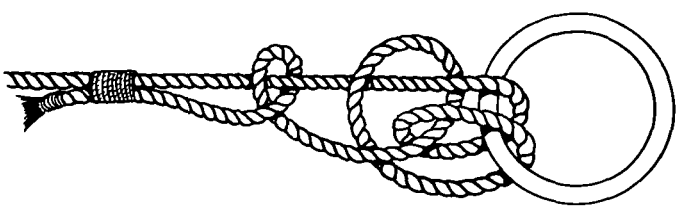


Figure 65. Anchor hitch.

A **SHEEPSHANK** is a method of shortening a rope without cutting it. It may also be used to take the load off of a weak spot in the rope.

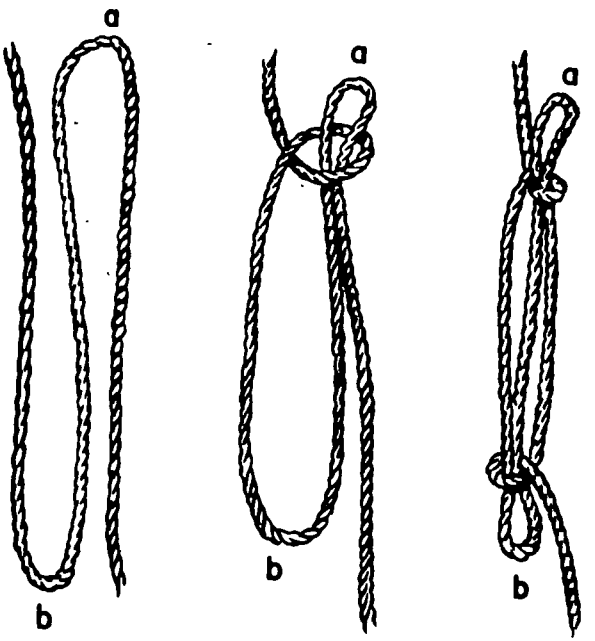


Figure 66. Sheepshank.

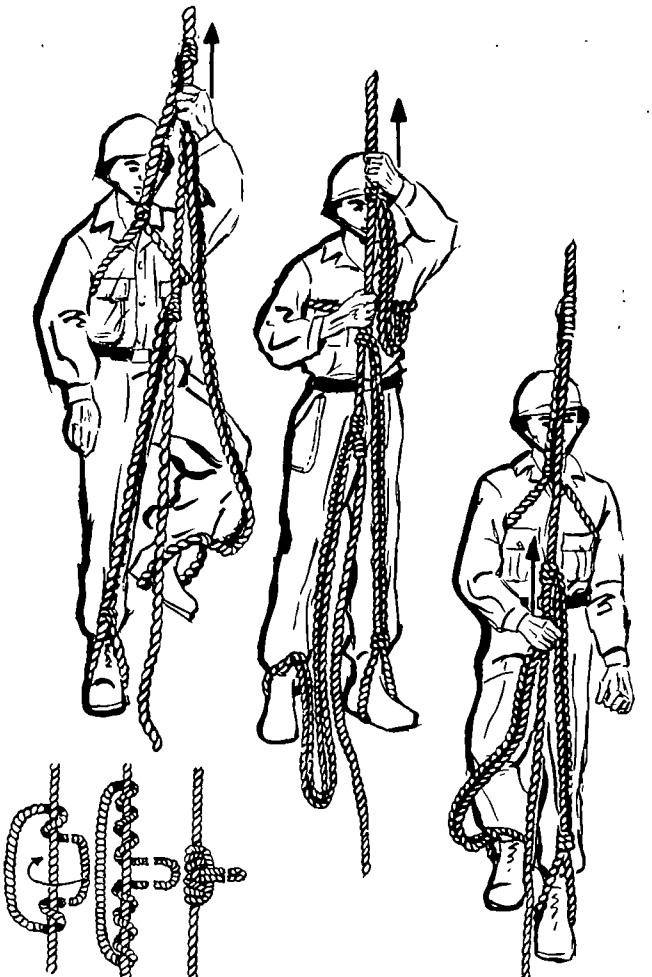


Figure 67. Prusik knot.

A knot that is used often in floot bridging is **BELAYING TO A CLEAT.** It is easily and quickly tied and untied.

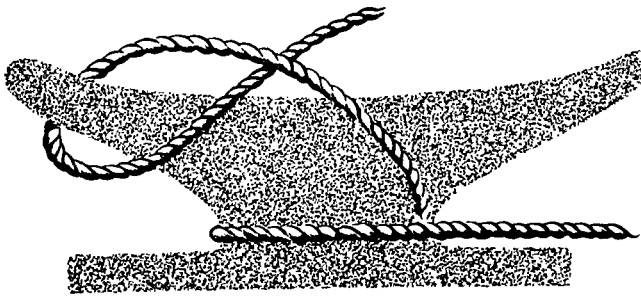


Figure 68. Belaying to a cleat.

24. Wire Rope Attachments

To obtain maximum strength at any joining of wire rope ends, each end should be made up into an eye splice and an end fitting of clips or clamps used to complete the eye. The wire can then be joined to another wire, hook, ring, or link of chain directly or by using a shackle.

a. Clips. Clips (1, fig. 75) may be used in making eyes in wire rope, either for a simple eye or an eye reinforced with a thimble. A thimble should be used for every eye, unless prevented by special circumstances. The thimble protects the rope from sharp bends around pins. To install the clips correctly, slip the U-bolts over the running end (short end) of the rope. The bases of the clips are placed in position over the U-bolt, so that they bear against the long end (standing end) of the rope. For best results, clips should

LASHING is the wrapping of rope around two or more pieces of timber (usually referred to as spars or legs) to fasten them together. Shown here are two methods of lashing three spars to form a tripod.

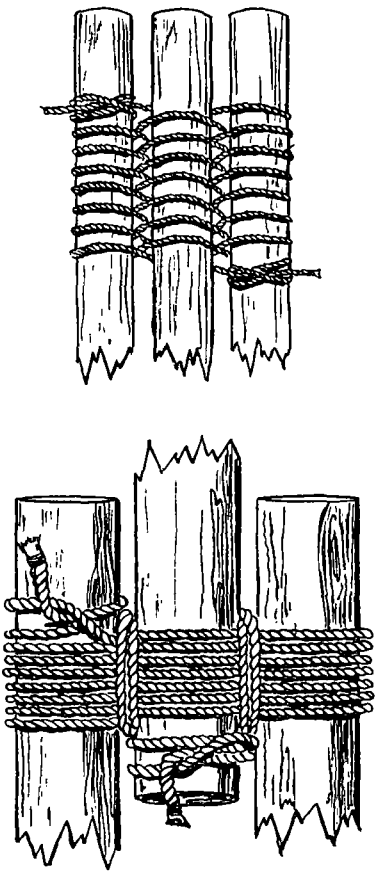
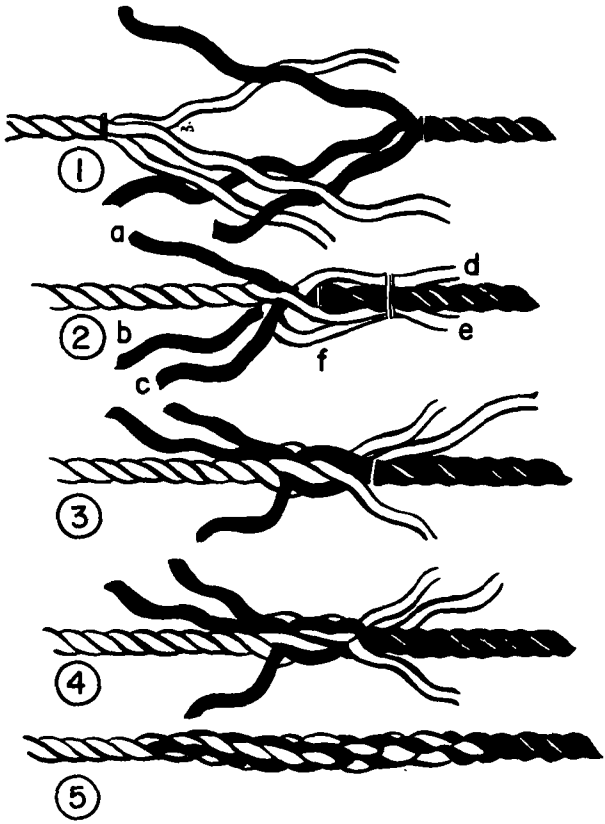


Figure 69. Lashing for a tripod.



The SHORT SPLICE causes an increase in the diameter of the rope for a short distance and can be used only where this increase will not affect operations.

Figure 70. Short splice.

The **EYE SPLICE** is used for making a permanent loop in the end of a rope.

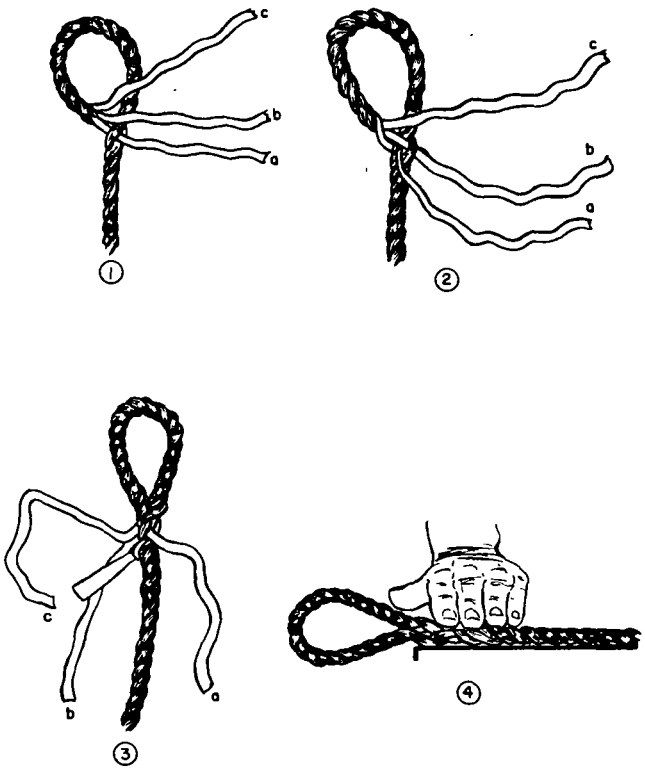


Figure 71. Eye splice.

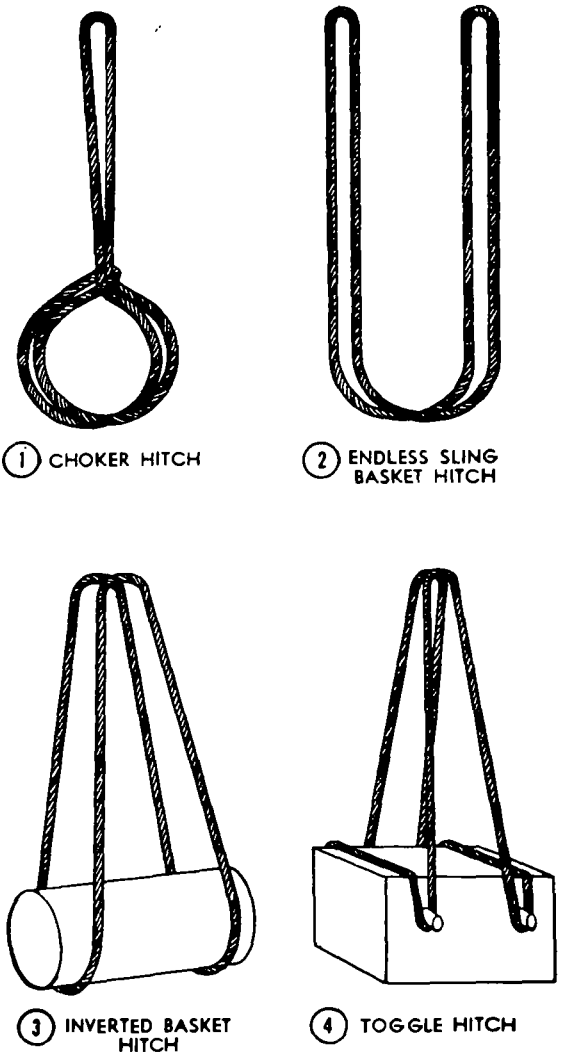


Figure 72. Methods of using endess slings.

be placed about six rope diameters apart. To determine the number of clips required, multiply the diameter of the rope by 3 and add 1. For example, the number of clips required for a 1-inch rope is: $1 \times 3 + 1 = 4$. When the calculation results in a fraction, use the next higher whole number. A minimum of 3 clips are required.

b. Clamps. A wire clamp (2, fig. 75) can be used with or without a thimble to make an eye in wire rope. Ordinarily, a clamp is used to make an eye without a thimble. When using the clamp, tighten the two end collars with wrenches to force the clamp to a good snug fit. This crushes the pieces of rope firmly against each other.

25. Blocks and Tackle

The parts of a block are the shell or frame, the sheave or wheel upon which the rope runs, the pin upon which the wheel turns in the shell and the becket. Blocks are designated by the length of the shell in inches and the number of sheaves. Those with one, two, three, or four sheaves are called single, double, triple, or quadruple. The smallest size block (length in inches) that will take a given rope is nine times the rope diameter. Self-lubricating blocks should be used whenever obtainable. Types of blocks are illustrated in figure 76.

a. Definitions.

(1) *Snatch block.* A snatch block is a single block with the shell opening at one side

to admit a rope without passing the end of the rope through.

(2) *Running block.* A running block is attached to the object to be moved.

(3) *Standing block.* A standing block is fixed to some stationary object.

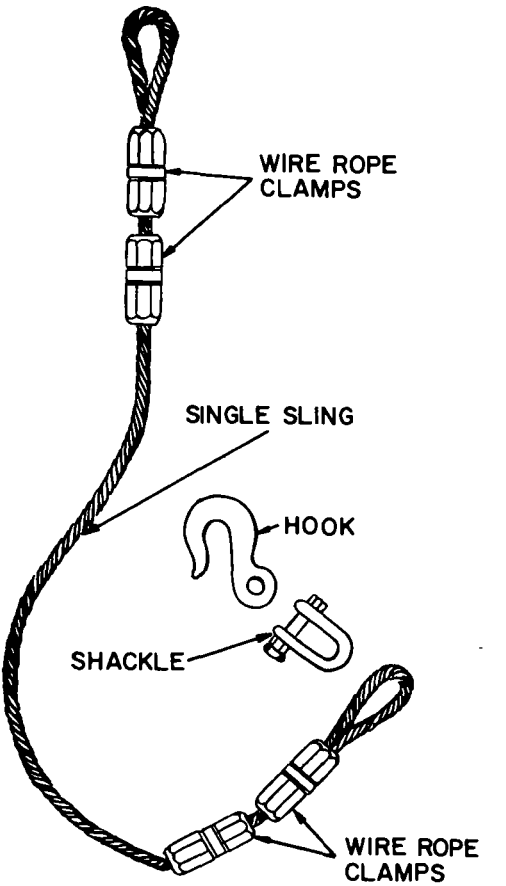
(4) *Simple tackle.* A simple tackle consists of one or more blocks reeved with a single rope.

b. Mechanical Advantage. The mechanical advantage of the block and tackle is found by dividing units of weight lifted by units of pull (force) necessary to lift it. In simple tackles, the mechanical advantage gained is a direct function of the number of ropes *supporting* the load. Thus, if the movable block is a double one, four or five ropes will sustain the load (depending on the direction of pull) and the mechanical advantage is four or five to one. Figures 77 and 78 illustrate the use of block and tackle and show the mechanical advantage obtained.

26. Boatswain's Chair

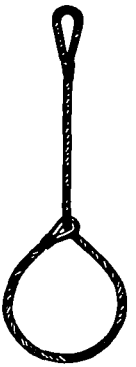
A boatswain's chair is a simple sling or seat for one man. It may be constructed in several forms, but generally consists of a rope sling for supporting one man.

a. Rope Chair. A rope boatswain's chair (1, fig. 79) can be made by using a double bowline and a rolling or magnus hitch. One man can operate the rope seat to lower himself by releasing the knot on the standing part of the rope.

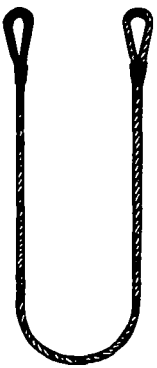


A **SINGLE SLING** may be made of wire rope, fiber rope, or chain. Each end of the sling is made up into an eye, or has a hook attached.

Figure 73. Single sling components.

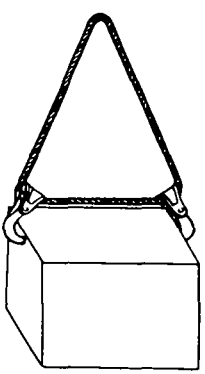


(1) CHOKER HITCH

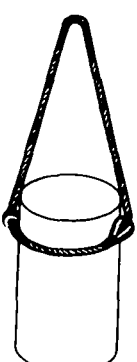


(2) BASKET HITCH

Two methods of using single slings are the **CHOKER HITCH** ① and the **BASKET HITCH** ②.



(3) STONE DOG HITCH

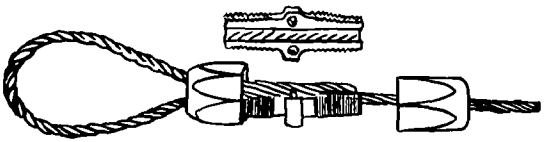


(4) DOUBLE ANCHOR HITCH

Single slings with two hooks are used sometimes for lifting stone and are known as **STONE DOG HITCHES** ③. Another application of a single sling is the **DOUBLE ANCHOR HITCH** ④, which is used for hoisting drums or other cylindrical objects where it is necessary for the sling to tighten itself under strain and lift by friction against the sides of the cylinder.

Figure 74. Method of using single slings.

① WIRE ROPE CLIPS



② WIRE ROPE CLAMP

Figure 75. Method of attaching wire rope clips and clamps.

b. Rope Chair With Seat. If the rope boatswain's chair must be used to support a man at work for some time, the rope may cause considerable discomfort. A notched board (2, fig. 79) inserted through the two leg loops will provide a comfortable seat. The loop formed as the running end to make the double bowline will still provide a back support, and the rolling hitch can still be used to lower the boatswain's chair.

27. Anchorages

Natural, temporary, or permanent anchorages may be used in rigging for securing guylines or anchoring any other lines. Figures 80 through 83 illustrate various anchorages commonly used.

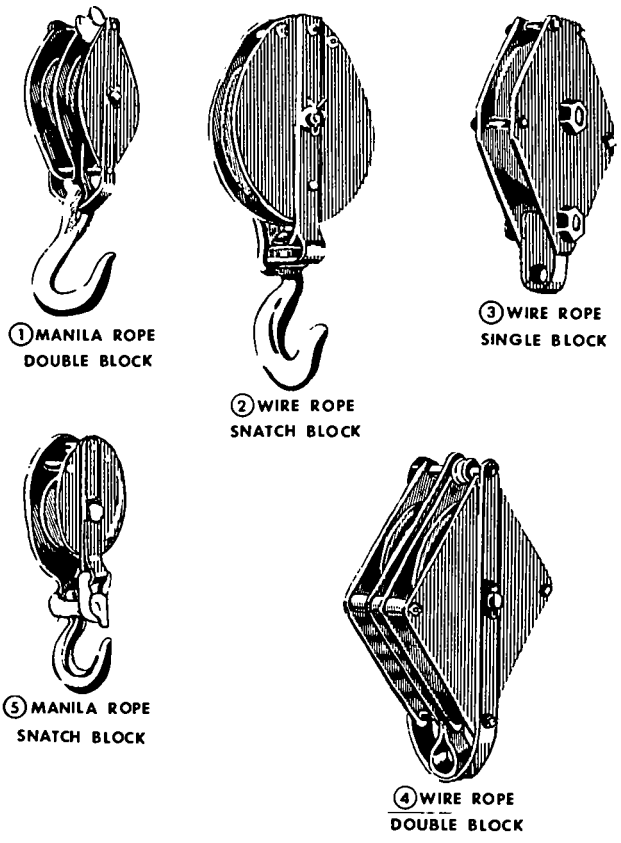


Figure 76. Types of blocks.

28. Lifting and Moving Loads

With an elementary knowledge of rigging, rope, tackle, and timber, devices can be made in the field to assist greatly in lifting or moving heavy loads.

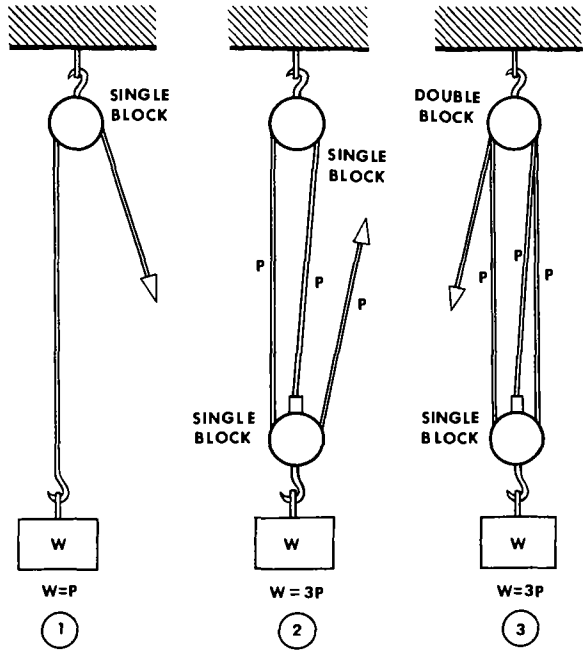


Figure 77. Examples of simple tackle.

These devices are called gin poles, tripods, shears, and boom derricks. Figure 84 through 88 show each of these devices.

29. Cableways and Tramways

Aerial transportation installations can be divided into two general groups, cableways (sometimes referred to as "high lines") and tramways.

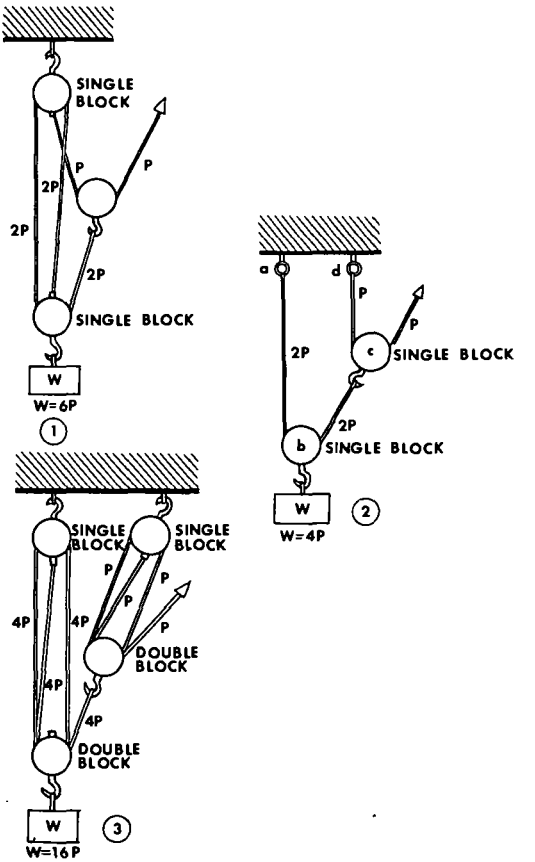
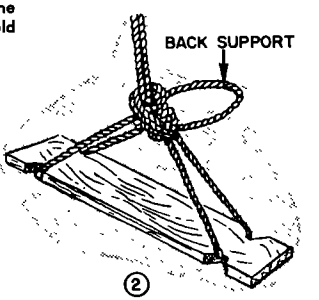


Figure 78. Examples of compound tackle.

①

BOATSWAIN'S CHAIR. ① A slight twist with the hond on the knot permits the suspension line to slip through it, but when the hond pressure on the knot is released, the knot will hold firmly.

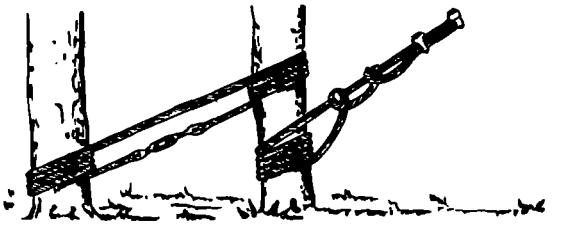


②

① Boatswoin's choir with seat.

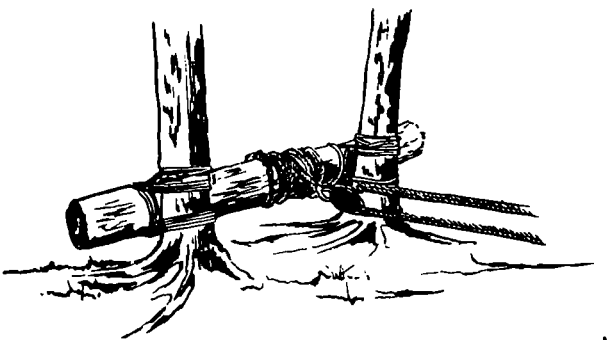
Figure 79. Boatswain's chair.

The basic difference between the two is that intermediate towers are not used with cableways but they are required with tramways. A cableway is used to cross a single depression or stream that would otherwise be difficult to traverse. Tramways are used to cross a series of depressions or a rugged ground surface with abrupt changes in slope. The distances covered by tramways can be much greater because of the intermediate towers. Figure 89 shows a cableway installation.



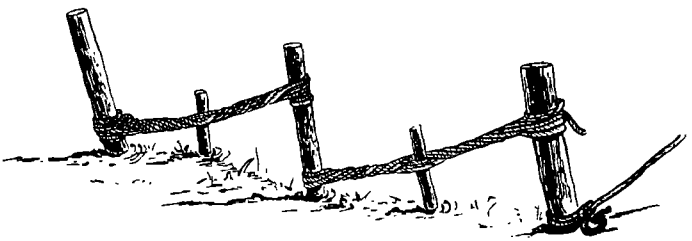
Use of two trees as natural anchorage.

Using a rock for natural anchorage.

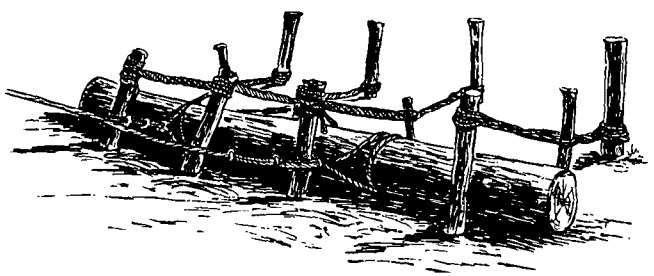


Use of trees or stumps and transom as natural anchorage.

Figure 80. Examples of natural anchorages.

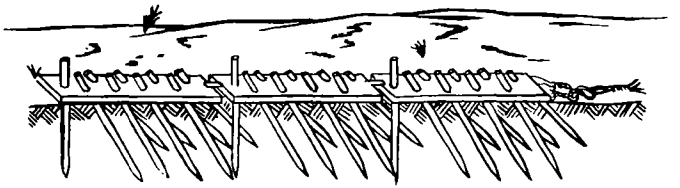


To make a **MULTIPLE HOLDFAST,** pickets at least 3 inches in diameter and 5 feet long are driven into the ground 3 feet and spaced 3 to 6 feet apart, being careful to keep them in line with the guyrope.



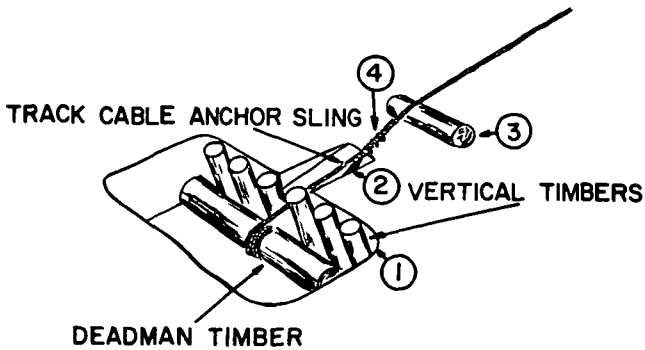
COMBINATIONS. For heavy loading, it is desirable to spread the load over the largest possible area of ground. This is accomplished by increasing the number of pickets used. Four or five multiple holdfasts can be made up parallel to each other with a heavy log resting against the front pickets to form a combination log picket holdfast. The guyline or anchor is fastened to the log which bears evenly against the pickets.

Figure 81. Picket holdfasts.



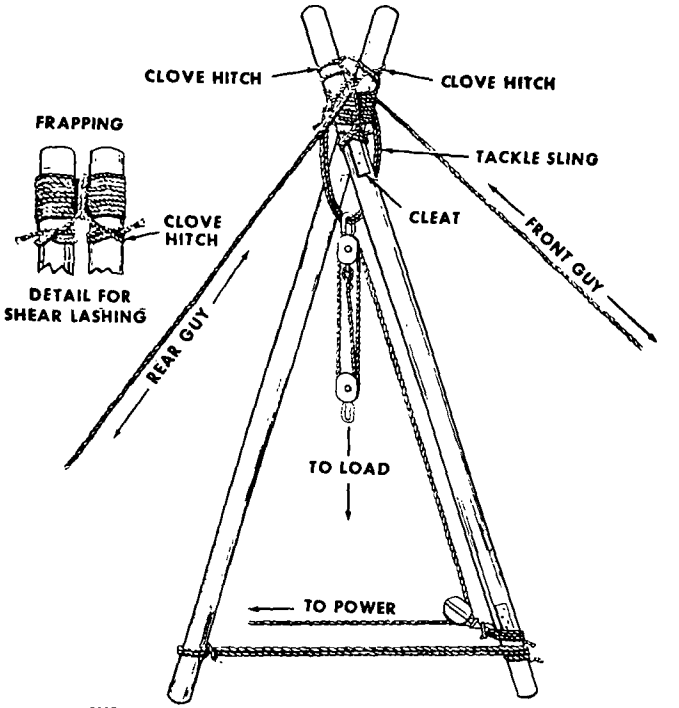
A standard **STEEL PICKET HOLDFAST** is available on issue or can be easily fabricated. It consists of a steel plate with nine holes drilled through it and a steel eye welded on the end for attaching the guyline. The steel pickets are driven through the holes in a manner that clinches the pickets in the ground. This holdfast is especially adapted for anchoring horizontal lines, such as the anchor cable on a pontoon bridge.

Figure 82. Steel pickets and plate.



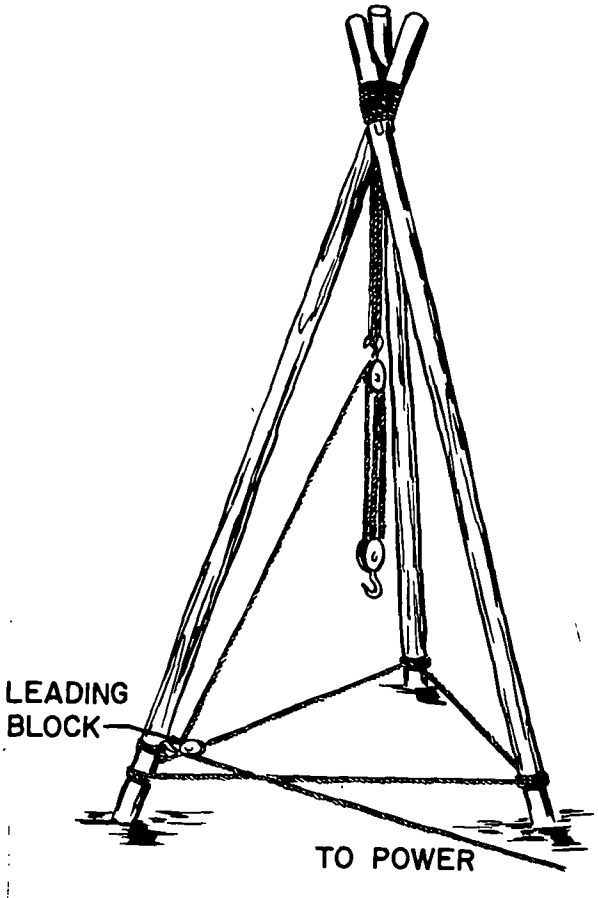
① Undercut the bank in direction of guyline about 15°.
② A norrow inclined trench should be cut for the guyline.
③ It is advisoble to ploce a short log under the guyline at outlet of the inclined trench.
④ The running port of the guyline should be secured on the outside of the trench for inspections and mointenonce.

Figure 83. Deadman.



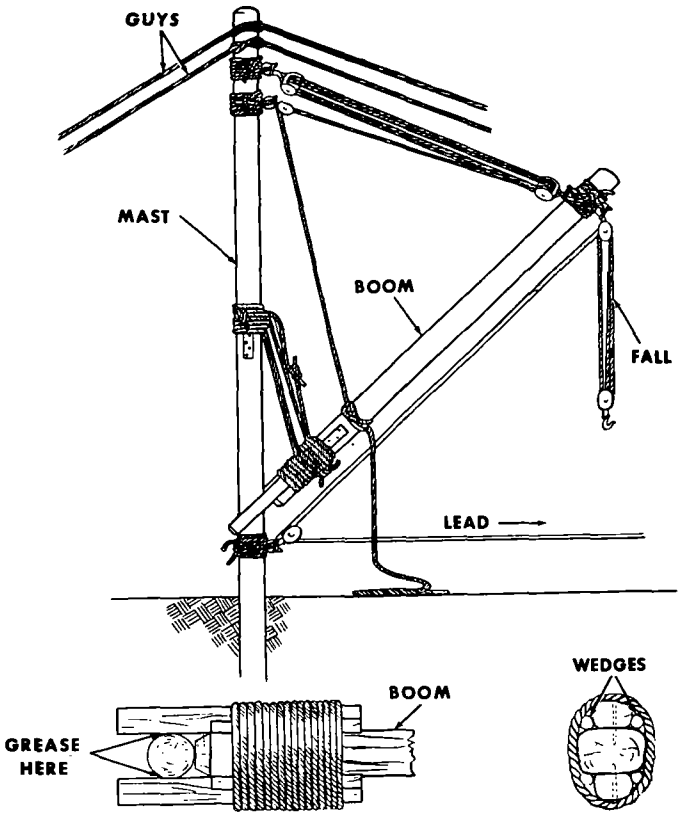
SHEARS are easily assembled and require only two guys, and are adaptable to working at an inclination from the vertical. In addition to their hoisting and lifting capabilities, shears are used extensively as towers for cableways and in floating bridge operations.

Figure 84. Shears.



A TRIPOD consists of three legs lashed at the top. Its advantage over other devices is its stability. Its disadvantage is that the load can be moved only up and down.

Figure 85. Tripod.



BOOMS are used on gin poles to lift loads placed at distances from the base of the gin pole that the drift on the pole would overload the guyline. For medium loads the boom can swing about the gin pole.

Figure 86. Boom derrick.

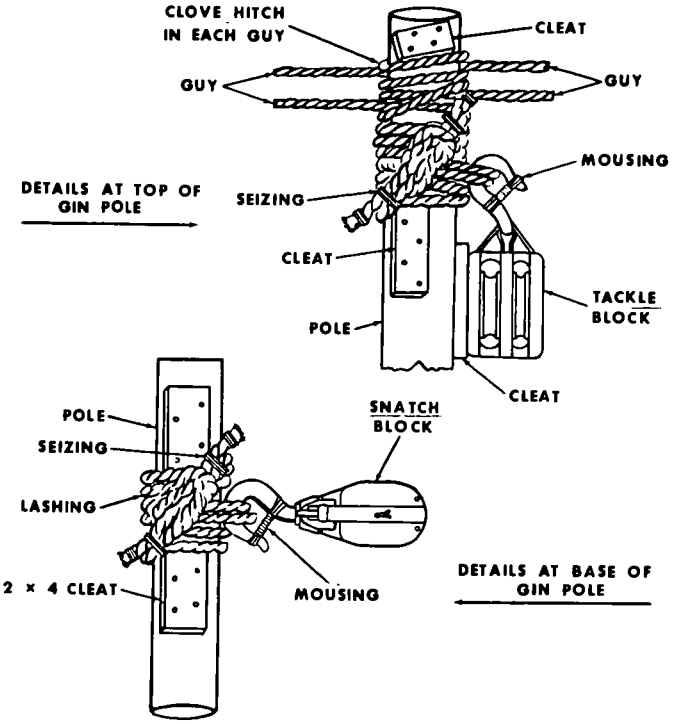


Figure 87. Details of boom derrick.

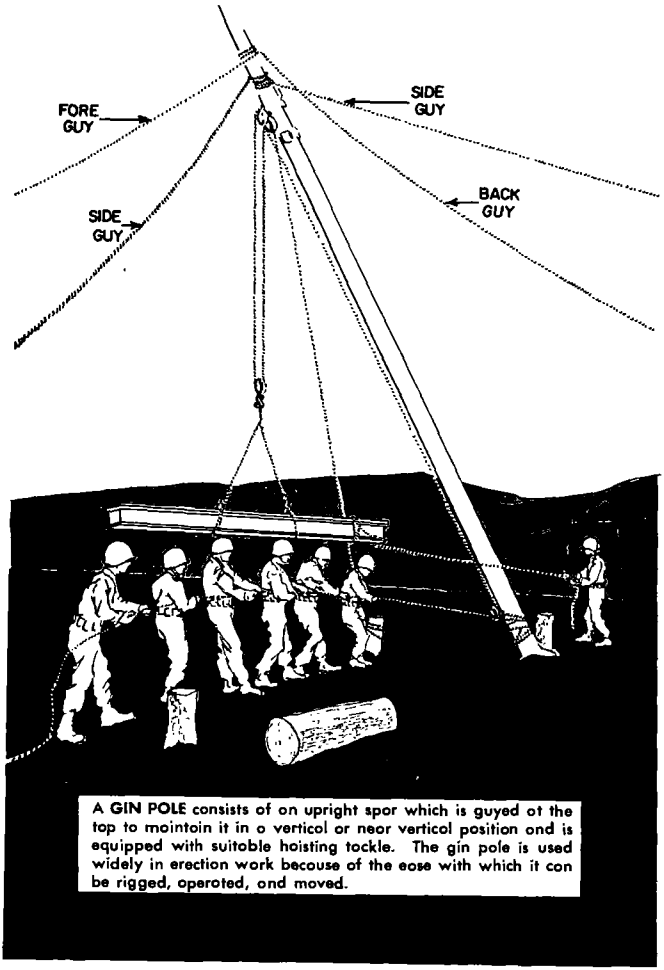


Figure 88. Hoisting with a gin pole.

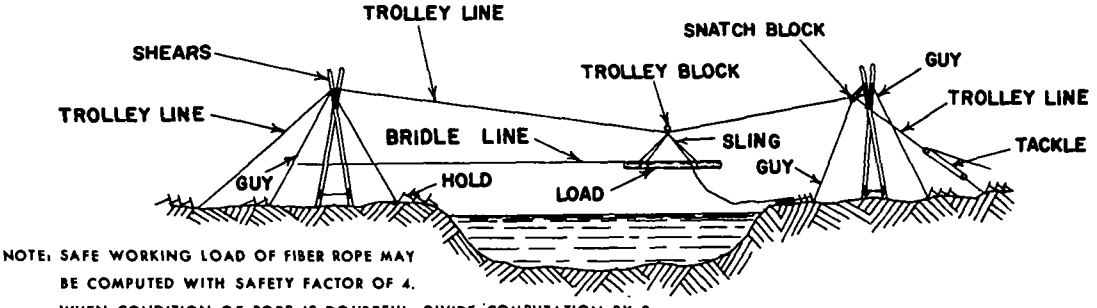


Figure 89. Cableway.

CHAPTER 4

EXPLOSIVES AND DEMOLITIONS

30. The Job of Destruction

As an engineer soldier, you will be required to work with explosives on demolition projects. This chapter presents only the fundamental uses of explosives and is not intended to make you an expert. For a more thorough understanding of the principles and uses of explosives, refer to FM 5–25.

31. Standard Explosives

The standard types of explosives used for military purposes are shown in table I. The table indicates their principal uses; however, they may be employed for other purposes when necessary. In using the table to determine the proper type of explosive to be used for a specific purpose, the velocity of detonation must be considered. Explosives with a high velocity of detonation are generally used for cutting and breaching, while those with a lower detonating velocity are used for cratering, ditching, and quarrying.

a. TNT (Trinitrotoluene). Trinitrotoluene (fig. 90), commonly known as TNT, is one of the least sensitive of military high explosives. TNT is rea-

sonably stable in any climate, is not affected by moisture, and is one of the best explosives for underwater use.

(1) *Packaging.* TNT is packaged in ½-pound, 1-pound, and 8-pound blocks as follows:

(*a*) The ½-pound blocks (fig. 90) are contained in an olive drab wrapper with metal ends. One end is provided with a cap well to receive an electric or nonelectric blasting cap.

(*b*) The 1-pound block consists of two ½-pound blocks wrapped in an olive drab container with metal ends. One end of the container is threaded to receive priming adapters and standard bases of firing devices.

(*c*) The 8-pound block is made of cast TNT and is individually wrapped in a waterproof material and sealed.

(2) *Uses.* TNT is employed extensively for general military use in forward combat areas. The ½- and 1-pound blocks are used primarily for cutting and breaching projects, while the 8-pound block is used mainly as an auxiliary charge to the M6 antitank mine.

(3) *Detonation.* TNT is not usually exploded by a cap less powerful than the electric (Type II (J2 PETN and M–6)) or nonelectric (Type I (J1 PETN and M–7)). It may also be detonated by detonating

Table I. Characteristics of Principal United States Explosives

Name	Principal use	Smallest cap required for detonation	Velocity of Detonation (ft per sec)	Relative effectiveness as external charge (TNT–1.00)	Intensity of poisonous fumes	Water resistance
TNT	Main charge, booster charge, cutting and breaching charge, general and military use in forward areas.	Spec. blasting cap, electric or nonelectric.	21,000	1.00	Dangerous	Excellent
Tetrytol			23,000	1.20	Dangerous	Excellent
Composition C3			26,000	1.34	Dangerous	Good
Composition C4			26,000	1.34	Slight	Excellent
Ammonium Nitrate	Cratering and ditching		11,000	0.42	Dangerous	Poor
Military Dynamite M1	Quarry and rock cuts		20,000	0.92	Dangerous	Good

PETN	Detonating cord	Spec. blasting cap*	24,000	1.66	Slight	Good
	Blasting caps	N/A				
TETRYL	Booster charge	Spec. blasting cap*	23,400	1.25	Dangerous	Excellent
	Blasting caps	N/A				
Composition B	Bangalore torpedo	Spec. blasting cap, electric or nonelectric.	25,500	1.35	Dangerous	Excellent
Amatol 80/20	Bangalore torpedo		16,000	1.17	Dangerous	Poor
Black Powder	Time blasting fuze	N/A	(unknown)	0.55	Dangerous	Poor

* Electric or nonelectric.

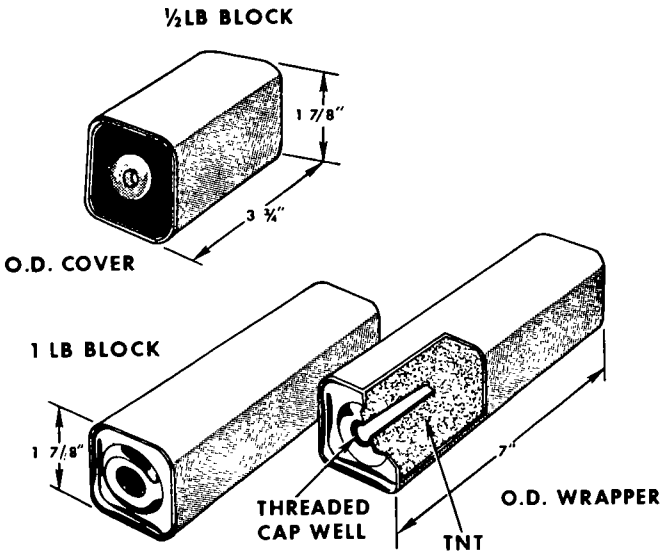


Figure 90. TNT blocks.

cord and any of the firing devices using the J1 blasting cap.

b. Tetrytol (M1 Chain Demolition Blocks). Tetrytol has all the desirable characteristics of TNT and is slightly more powerful. It is effective as a breaching charge, but is not desirable as a cratering charge. Tetrytol is slightly soluble in water, brittle, and breaks easily when dropped.

(1) *Packaging.* Tetrytol is packaged in 2½-pound blocks inclosed in an olive drab asphalt-impregnated paper wrapper (fig.

91). Eight blocks, 8 inches apart, are cast into a single line of detonating cord which passes lengthwise through them. One chain (8 blocks) is packed in an olive drab haversack with an attached carrying strap, and two haversacks are packed in a wooden box.

(2) *Uses.* The entire chain, or any part of the chain, may be used laid in a line, wrapped around an object, or as it is packed in the haversack. If less than the 8 blocks are needed, the required number may be cut from the chain with 8 inches

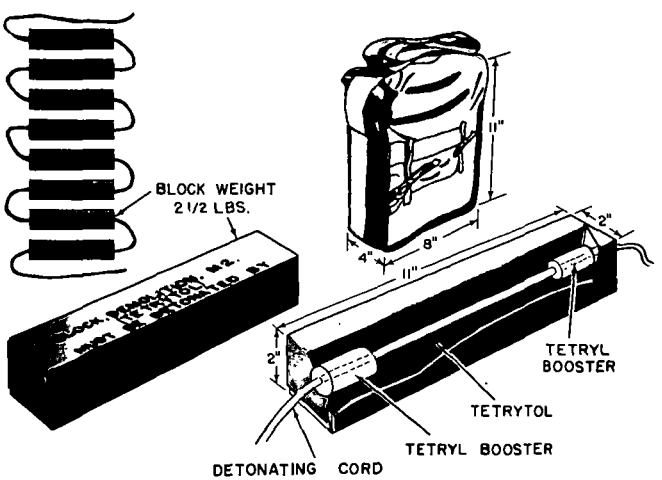


Figure 91. M1 chain demolition blocks.

of detonating cord left attached to each block. The blocks may be broken up to be used in small diameter boreholes. When the blocks are broken up for this purpose, a booster must be made from TNT or plastic explosives and primed to insure detonation of the charge.

(3) *Detonation.* Tetrytol can be detonated by either electric or nonelectric caps. It may also be detonated by detonating cord or any of the firing devices using the J1 blasting cap. (See table I for detonation velocity.)

c. Composition C3 (M5 Demolition Block). Composition C3 (fig. 92) is a plastic explosive more powerful than TNT. At temperatures below minus 20° F., the explosive becomes hard and brittle; at temperatures above 120° F., it becomes extremely soft and exudes some of its oils.

(1) *Packaging.* Composition C3 is packaged as a block in glazed paper and is inclosed in an olive drab cardboard container. Each block weighs 2¼ pounds and there are 8 blocks to a haversack. Two of these haversacks are packed in a wooden box.

(2) *Uses.* Composition C3, because of its high velocity of detonation and plasticity, is ideally suited for cutting steel. Its plasticity permits close contact to irregularly shaped objects for demolition purposes. This explosive may be used as an underwater charge, if it is inclosed in a

suitable container to prevent erosion by water.

(3) *Detonation.* Composition C3 may be detonated with the special blasting cap, either electric or nonelectric. (See table I for detonation velocity.)

d. Composition C4 (M5A1 Demolition Block). Composition C4 (fig. 93) is a white plastic explosive, more powerful than TNT. Composition C4 is more stable than C3 and less subject to erosion when used as an underwater charge. At temperatures below —70° F., the explosive becomes hard and brittle; at temperatures above 170° F., it becomes extremely soft and exudes some of its oils.

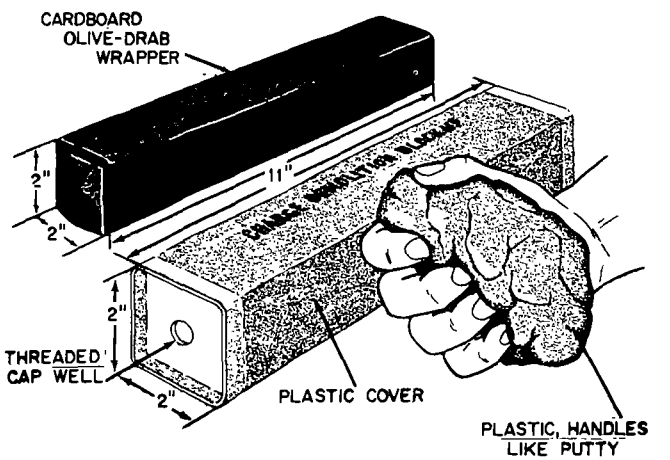


Figure 92. M5 demolition block.

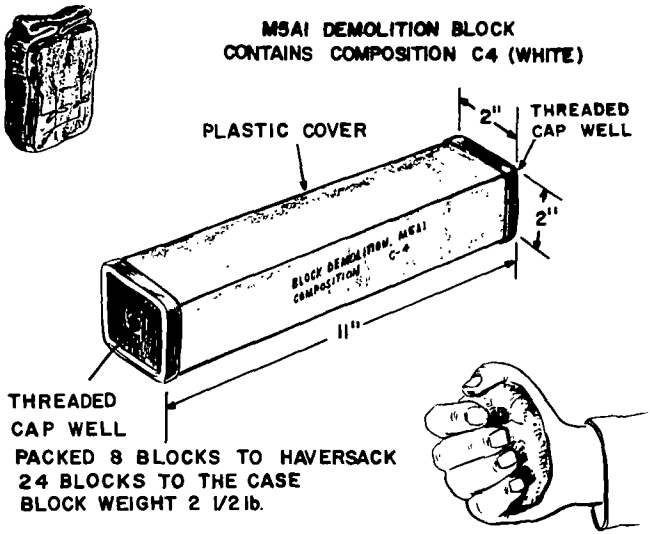


Figure 93. M5A1 demolition block.

(1) *Packaging.* Composition C4 is packaged as M5A1 demolition blocks, each weighing 2½ pounds. The blocks are wrapped in a plastic covering with a threaded cap well in one end. Eight blocks are placed in a haversack and two haversacks are packed in a wooden box.

(2) *Uses.* Composition C4, because of its high velocity of detonation, is ideally suited for cutting steel, timber, and breaching concrete. Its plasticity permits close contact for the demolition of irregularly shaped objects.

(3) *Detonation.* Composition C4 may be detonated with the special blasting cap, either electric or nonelectric. It may also be detonated by detonating cord and any of the firing devices using the J1 blasting cap. (See table I for detonation velocity.)

e. Shaped Charges.

(1) *Uses.* A shaped charge (fig. 94) is an explosive charge designed to concentrate the explosive forces for penetration of steel, armor, concrete, and other masonry. A threaded cap well in the top of the charge receives any standard firing device. Expedient shaped charges are described in paragraph 38*b*. The shaped charge may be detonated either electrically or nonelectrically.

(2) *Special precautions in use.* In using shaped charges, the following precautions should be observed:

(*a*) The charge should be centered over the point to be attacked.

(*b*) The axis of the charge should be in line with the direction of the hole desired.

(*c*) The pedestal provided should be used to obtain the proper standoff distance.

(*d*) There should be no obstruction in the conical cavity or between the charge and the target since any obstruction will reduce the penetration effect.

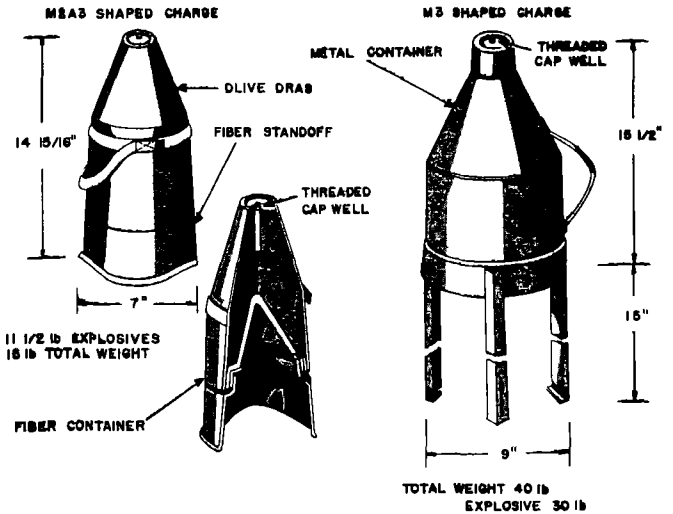


Figure 94. Shaped charges.

(*e*) Personnel in the open should withdraw at least 900 feet or take appropriate cover before firing, due to missile hazard.

f. Cratering Charge. The cratering charge (fig. 95) uses ammonium nitrate or nitramon as the explosive. This explosive has a low velocity of detonation and is ideally suited for cratering purposes.

(1) *Packaging.* The cratering charge is packaged in a watertight, cylindrical metal container. The charge is 8¼ inches in diameter by 17 inches high and weighs 40 pounds, while the nitramon

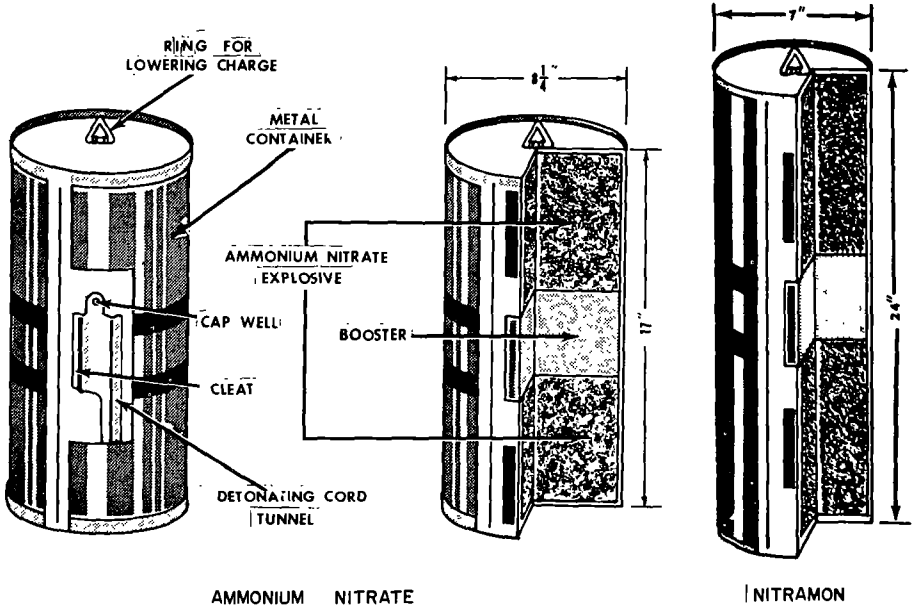


Figure 95. Cratering charges.

cratering charge is issued in cylindrical metal containers 7 inches in diameter, 24 inches long, and weighs 43 pounds. A cap well and a detonating cord tunnel are attached to the side of the container to permit priming. A metal ring on the top is provided for lowering the charge into a hole.

(2) *Uses.* In addition to cratering, this charge can also be used in ditching and quarrying.

(3) *Detonation.* The cratering charge can be exploded by the special blasting cap, electric or nonelectric, or by detonating cord. However, due to frequency of misfires it is recommended that a separate primer consisting of a 1-pound charge be placed on top of the container in each hole.

g. Bangalore Torpedo. The bangalore torpedo (fig. 96) consists of a series of assemblies which can be used separately or in a series by connecting them together with a connecting sleeve. In joining two or more assemblies, a nose sleeve is used on the front end of the torpedo to help push the torpedo through entanglements and across the ground. Any length of pipe with approximately a 2-inch inside diameter and a wall thickness of at least 0.025 inch (24 gage) can be made into an expedient bangalore torpedo by packing it with about 2 pounds of explosives per linear foot and providing suitable priming means.

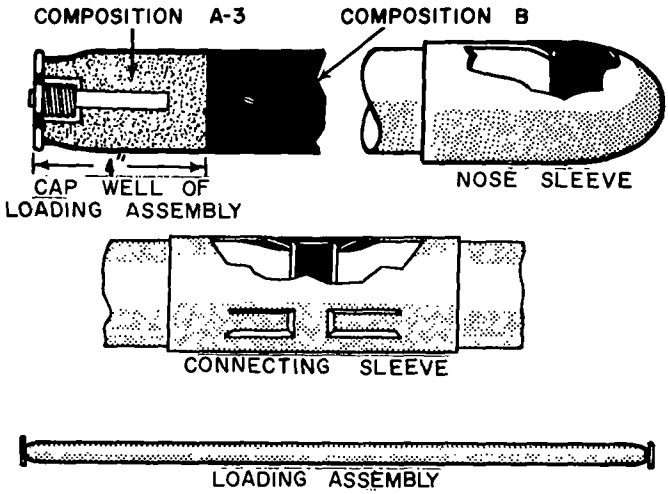


Figure 96. Components of M1A2 bangalore torpedo.

(1) *Uses.* The bangalore torpedo is used primarily to clear a path through barbed wire entanglements. Used in this way it is pushed into position under the wire and detonated. The torpedo will clear a path from 3 to 5 meters wide through a wire entanglement. It can also be used to clear a path through a minefield and will explode antipersonnel and most antitank mines in close proximity. Since the cleared path is very narrow, some mines may be left in a sensitive state, demanding extreme care in any further mine clearing operations along the path.

(2) *Detonation.* The special blasting cap (electric or nonelectric) and detonating cord will detonate the bangalore torpedo. In tactical uses of the torpedo, the recommended firing methods are—using a nonelectric cap and time fuze; tying detonating cord with a clove hitch and two extra turns around the torpedo; or using a pull type firing device with a nonelectric blasting cap attached.

h. Rocket Propelled Bangalore Torpedo. This set (fig. 97) consists of 20 sections of bangalore torpedo which may be fitted together to make a 100-foot train. A kit contains the rocket motors, tail assemblies, and couplings for 20 sections. The rocket motor is fitted to the front of the train to provide propulsion. Detonation is effected by a tail assembly which is fitted to the rear end of the train and contains a pull fuze, a nonelectric blasting cap, and a reel of cable 400 feet long. The torpedo is assembled and pulled within range of the target on which it is to be used. The reel of cable is shortened to the length of propulsion desired before detonation and the free end is anchored firmly. The rocket motor is fired electrically and the train travels until the cable becomes taut and trips the pull fuze which detonates the assembly. The rocket motor system offers less exposure of personnel to enemy observation and fire. For further information on the use of the bangalore torpedo, see TM 5–220.

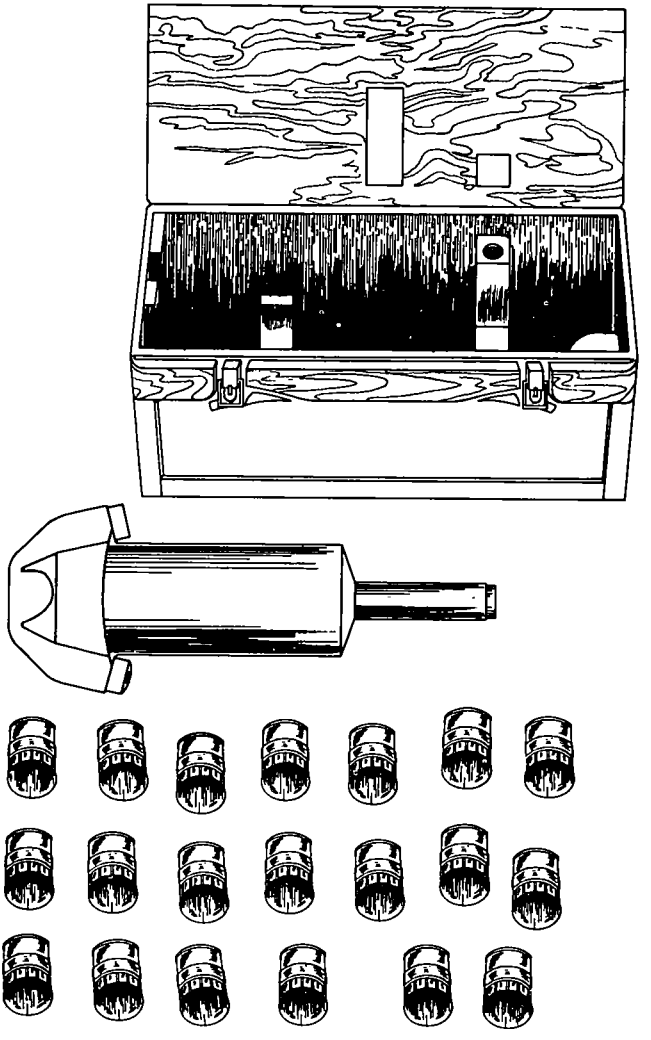


Figure 97. Rocket-propelled bangalore torpedo.

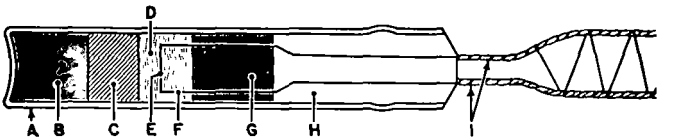
32. Blasting Equipment and Accessories

a. Blasting Caps. Blasting caps are used for initiating detonation in explosives and designed to be inserted into cap wells. The electric type cap is fitted with lead wires for attaching to a blasting machine. The nonelectric type is crimped to any standard firing device or time fuze (safety fuze) and fitted with a fuze lighter or to detonating cord.

(1) *Electric blasting caps.* Typical construction of an electric blasting cap is shown in figure 98. When two or more electric blasting caps are connected in the same circuit, they must be from the same manufacturers. This is essential to prevent misfires since blasting caps of different manufacturers do not have the same electrical characteristics. Manufacturers may be identified by the label and color of the cap.

(2) *Nonelectric blasting caps.* Typical construction of a nonelectric blasting cap is shown in figure 99. A nonelectric cap is difficult to waterproof and its use should be avoided underwater or in wet boreholes. If it becomes necessary to use nonelectric blasting caps in damp boreholes, they should be covered with a waterproofing material and fired as soon as possible after placing.

b. Blasting Machines. Blasting machines are small impulse type generators. The current nec-



A. METAL SHELL
B. DETONATING CHARGE
C. INTERMEDIATE CHARGE
D. IGNITING CHARGE
E. PLATINUM WIRE OR BRIDGE HEATED BY THE ELECTRIC CURRENT
F. ENDS OF LEAD WIRES SET IN IGNITING CHARGE
G. PLUG (ASPHALT)
H. FILLING MATERIAL
I. INSULATED LEAD WIRES

Figure 98. Typical construction of an electric blasting cap.

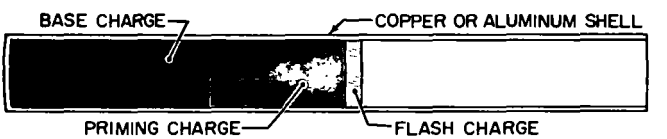


Figure 99. Typical construction of a nonelectric blasting cap.

essary for firing an electric circuit is generated by twisting the handle on the 10-cap blasting machine (fig. 100) and by a quick downward push of the plunger on the 30-cap blasting machine (fig. 101). The blasting machine should be connected to the circuit by the person who will actually fire the circuit. This individual should carry the machine, or at least its handle, on his person at all times during any demolition operation to prevent unauthorized use. He should also

connect the blasting cap wires to the firing circuit.

c. Galvanometer. The galvanometer (fig. 102) is an instrument used to test the continuity (uninterrupted connections) of electric firing circuits. It contains an electromagnet, a small special silver-chloride dry cell battery, and a scale with an indicator needle, all inclosed in a leather or canvas case. When the two external terminals on the galvanometer are connected in a closed circuit, the flow of current from the dry cell causes the needle to move across the scale.

(1) *Care.* The galvanometer must be handled with care and must be kept dry. It is a delicate instrument and should not be opened except when replacing the battery. The battery tends to cease functioning at temperatures below 0° F. When using the galvanometer in cold climates, it should be protected from freezing by placing it under the clothing near the body.

(2) *Precaution.* Use only the special *silver-chloride dry cell battery BA 245/U* in the galvanometer. Other batteries will cause detonation of blasting caps.

(3) *Testing.* The galvanometer should be tested prior to use by holding a piece of metal across the two exterior terminals. If a wide needle deflection does not occur, battery should be replaced and test repeated.

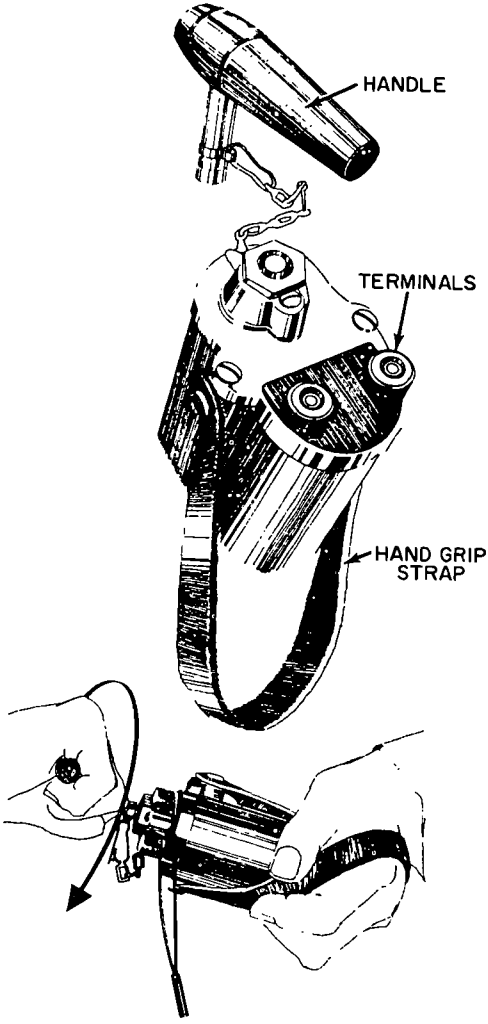


Figure 100. 10-cap blasting machine.

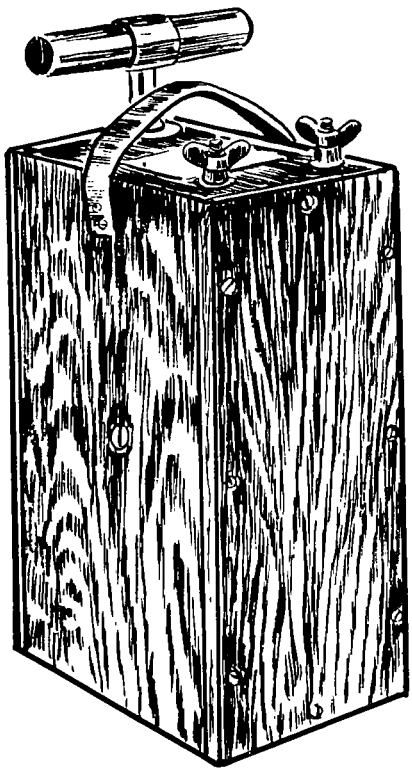


Figure 101. 30-cap blasting machine.

d. Time Fuze. The time fuze (fig. 103) contains black powder tightly wrapped in several layers of fabric and waterproofing materials. It may be any color with orange being the most common. It burns slowly and at a uniform rate,

Figure 102. Galvanometer.

allowing the person firing the charge to reach safety before the charge explodes. The rate of burning may vary between rolls from less than 30 seconds per foot to more than 45 seconds per foot; therefore, each roll of fuze should be timed shortly before use. The test is made by lighting a 1-foot cut section of fuze and timing the burning rate. The test section of fuze should be cut after discarding a 6-inch length from the running end. This test should be made as near as possible to the place where the actual firing will take place. The fuze may be lighted with a fuze lighter (*g* below) or a match. To use a match, split the end of the fuze and insert the head of an

unlighted match in the powder train. The head of the match is left protruding slightly and is ignited by drawing the abrasive side of the matchbox across it. The method of attaching the fuze to a nonelectric cap is described in *a*(2) above.

e. Detonating Cord. Detonating cord (fig. 104) consists of an explosive core of PETN covered with either white plastic, or yellow and black waterproof covering. It is detonated by the special blasting cap, electric or nonelectric. Its main use is to prime charges and simultaneously explode a number of separate charges. Detonating cord is particularly useful for priming explosives placed below the ground, or underwater. The following safety measures should be observed in handling and using detonating cord:

(1) Avoid kinks and sharp bends.

(2) Exercise special handling care in cold weather to avoid breaking the covering or the explosive train.

(3) Lay out detonating cord lines as straight as possible but do not stretch taut. Detonating cord tends to form a spiral as it is unwound from its spool. To avoid misfire it must be carefully straightened before firing.

(4) Do not remove any part of the fabric covering.

(5) Apply a sealing compound to the end of the cord when using in underwater charges, or in charges that are to be left in place for several hours before firing.

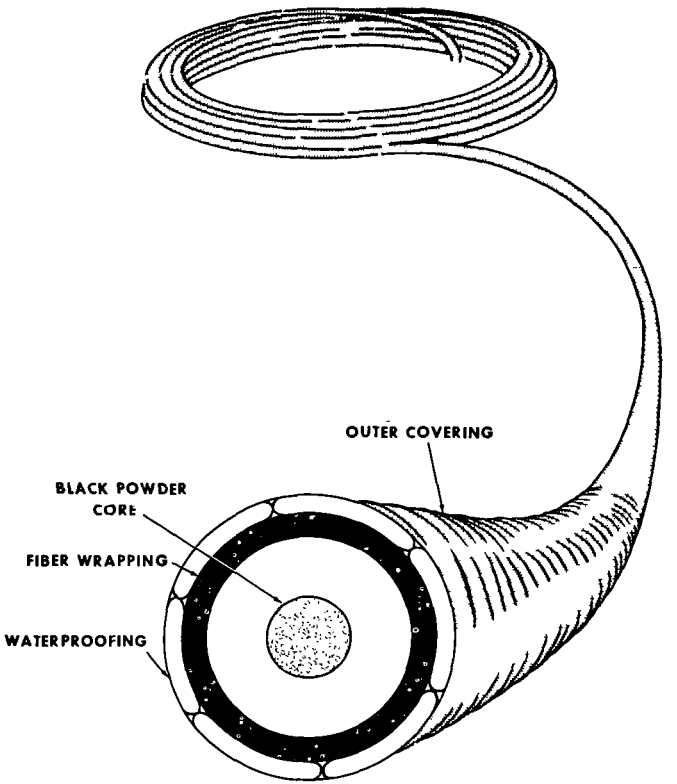


Figure 103. Blasting time fuze.

A 6-inch free end protects the remainder of the line from moisture for 24 hours.

f. Cap Crimpers. The M2 cap crimper (fig. 105) is designed to squeeze the shell of the non-

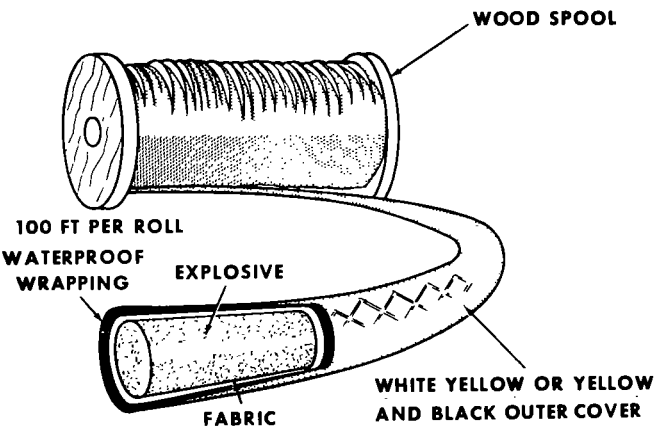


Figure 104. Detonating cord.

electric blasting cap around a time fuze, a standard base, or detonating cord to prevent separation. The M2 cap crimper crimps a water-resistant groove completely around the blasting cap. The lower portion of the jaw is shaped and sharpened for cutting fuze and detonating cord. One leg of the handle is pointed and is used for punching holes in explosives for the easy insertion of blasting caps. The other leg is shaped into a screwdriver. The cap crimpers are made from a soft, nonsparking metal.

g. Fuze Lighter. The M60 weatherproof fuze lighter (fig. 106) is designed to ignite time fuze M700 safety fuze under all weather conditions and under water. The fuze is inserted into a fuze

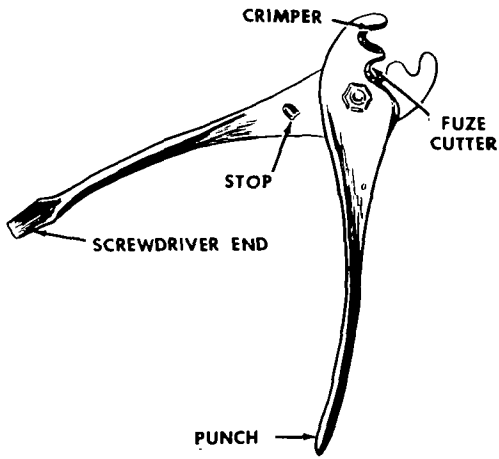


Figure 105. M2 cap crimper.

retainer and is sealed and waterproofed by means of two rubber seals. A pull on the pull ring releases the striker assembly, allowing the firing pin to drive against the primer igniting the fuze. The lighter is operated as follows:

(1) Unscrew the fuze holder cap two or three turns.

(2) Press the shipping plug into the lighter to release the split collet, and rotate the plug as it is removed.

(3) Insert a freshly cut end of time fuze in the place of the plug, until it rests against the primer.

(4) Tighten the cap sufficiently to hold the fuze tightly in place and thus waterproof the joint.

(5) To fire, remove the safety pin, hold the barrel in one hand, and pull ring with the other.

In the event of a suspected misfire, the M60 can be reset quickly without disassembly by pushing the plunger all the way in and attempting to fire as before. It cannot be reset underwater, however, because water can enter the interior of the nylon case through holes in the pull rod.

h. Rivet-Punching, Powder-Actuated Driver. This tool (fig. 107) is used for attaching fastenings to steel, concrete, and wood. The fastenings can be used to secure demolition charges. The tool can be used for and is specially suited for underwater work and areas of limited working space. The tool is hand-operated, air cooled, and feeds from a magazine which holds 10 fastening units. The fastening unit is propelled into the material by a specially-wadded caliber .38 shell case.

Figure 106. M60 fuze lighter.

Caution: **Do not fire the powder actuated driver into explosives or immediately adjacent to exposed explosives.**

33. Nonelectric Priming of TNT

a. If the block of TNT is provided with a threaded cap well, a priming adapter (fig. 108)

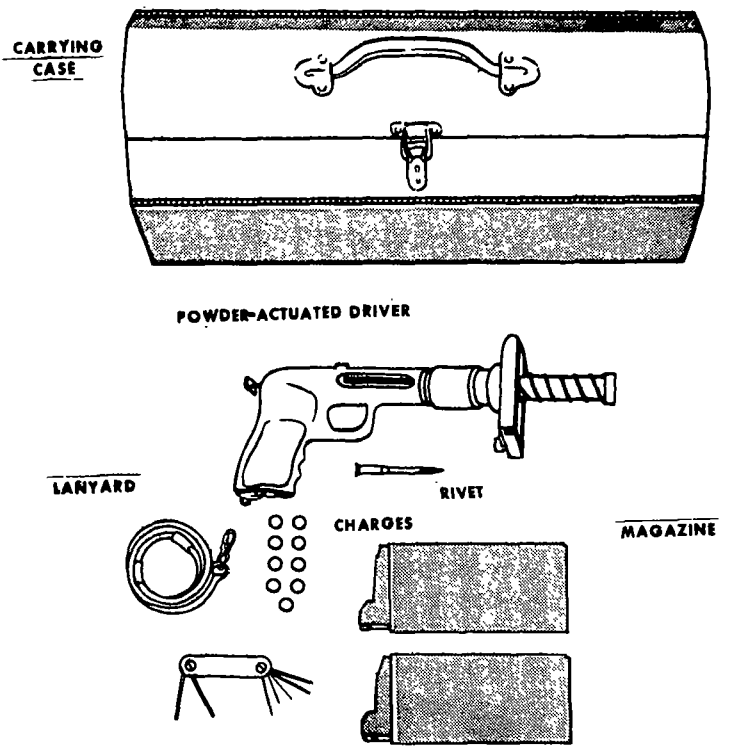


Figure 107. Rivet-punching, powder-actuated driver.

should be used. To use the priming adapter with time fuze or detonating cord:

(1) Slide the fuze or detonating cord through the adapter.

(2) Crimp a nonelectric blasting cap on the fuze or detonating cord.

(3) Slide the adapter down the fuze or detonating cord until the inside collar of the adapter contacts the blasting cap.

(4) Insert the cap and adapter into the threaded cap well and screw tightly.

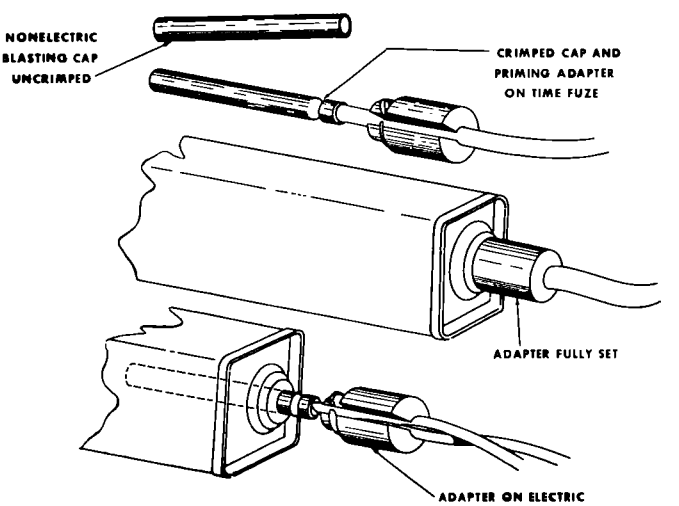


Figure 108. Method of using priming adapter with time fuze or detonating cord.

b. When priming adapters are not available, or when blocks do not have threaded cap wells, the following procedures may be used:

(1) *Using blasting cap and time or safety fuze.*

(*a*) Use the punch on the crimper and make a hole in the end of the block.

(*b*) Wrap a string tightly several turns around both axis of the block and tie, leaving at least 6 inches of loose string after the tie has been made.

(*c*) Insert the crimped cap and fuze into the hole and tie it securely with the loose string to prevent the fuze and cap from being pulled out of the block.

(2) *Using detonating cord.* Since detonating cord must be detonated itself with a blasting cap, it cannot properly be considered a primer. Detonating cord may be used, however, to detonate any number of high explosive charges, provided a single electric or nonelectric blasting cap is properly and securely attached to the cord. To prime TNT with detonating cord, the detonating cord is tied securely around the explosive charge by a clove hitch with an extra turn as shown in 1, figure 109. At least four complete turns are required to insure proper detonation. The cord must fit snugly against the block and the loops must be pushed together.

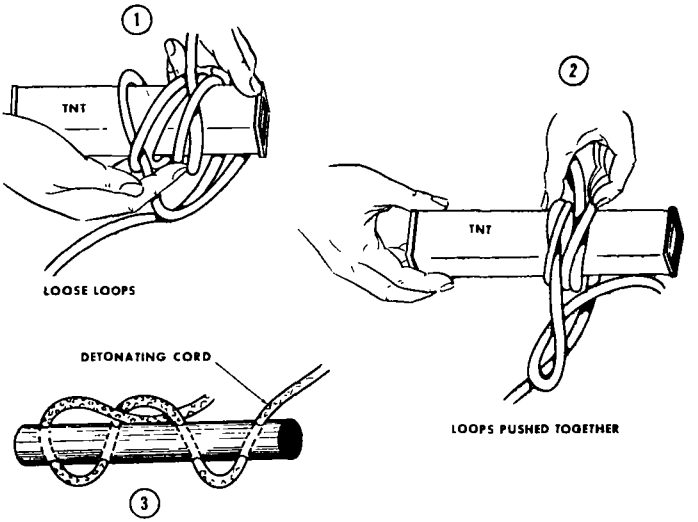


Figure 109. Priming TNT block with detonating cord.

34. Nonelectric Priming of Plastic Explosive (C3 and C4)

a. The blasting cap and time or safety fuze may be used with a priming adapter in the same manner as described for TNT in paragraphs 33 and 42*a*.

b. To prime with detonating cord:

(1) Take a 10-inch bight at the end of the detonating cord and tie with an overhand knot (1 and 2, fig. 111).

(2) Mold the explosive around the knot with at least ½-inch of explosive on all sides

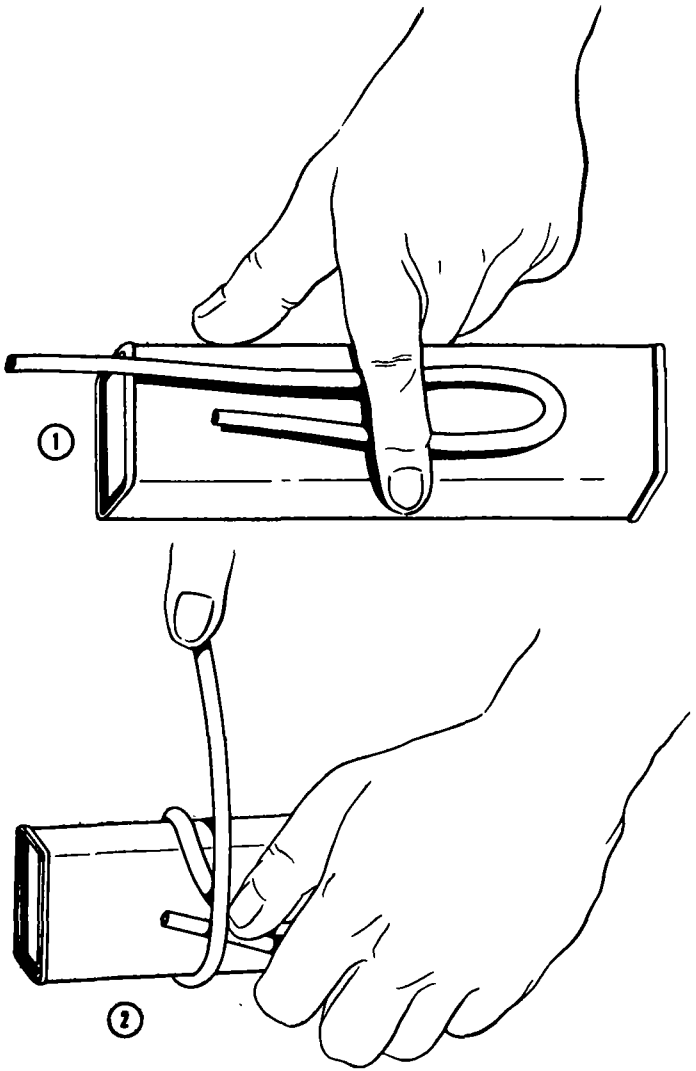


Figure 110. Aternate method of priming TNT with detonating cord.

and at least 1-inch on each end (3 and 4, fig. 111).

35. Priming M1 Chain Demolition Block With Detonating Cord

The M1 chain demolition block is manufactured with detonating cord running through the individual blocks to connect them into a chain. If additional cord is required, it is connected to the detonating cord of the chain with a clip or square knot. If the cord running through the blocks is cut too close to the end block to permit such a connection, the extra length of detonating cord is tied to the block by a clove hitch with two extra turns around the block.

36. Fastening Blasting Cap to Detonating Cord

a. Detonating cord is detonated by the use of either an electric or nonelectric blasting cap. The cap is taped or tied securely to the detonating cord (fig. 112) or fastened to the cord with a detonating-cord clip. The blasting cap must be placed with the closed end toward the charge.

b. A single cap properly fastened to two detonating cord lines will detonate both lines. Figure 113 shows the correct method of fastening a cap to two detonating cord lines.

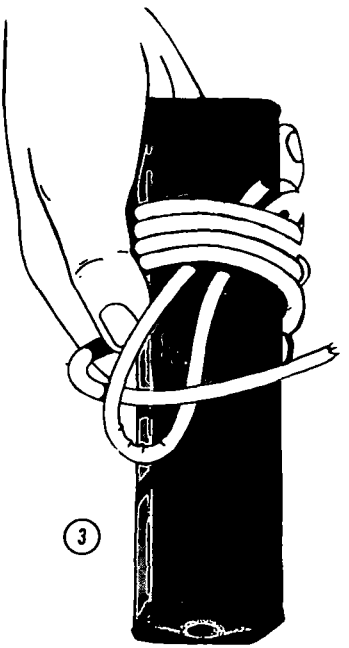


Figure 110—Continued.

37. Placement of Charges

The officer or noncommissioned officer in charge of each demolition project gives definite instructions as to the size of charges to be used and

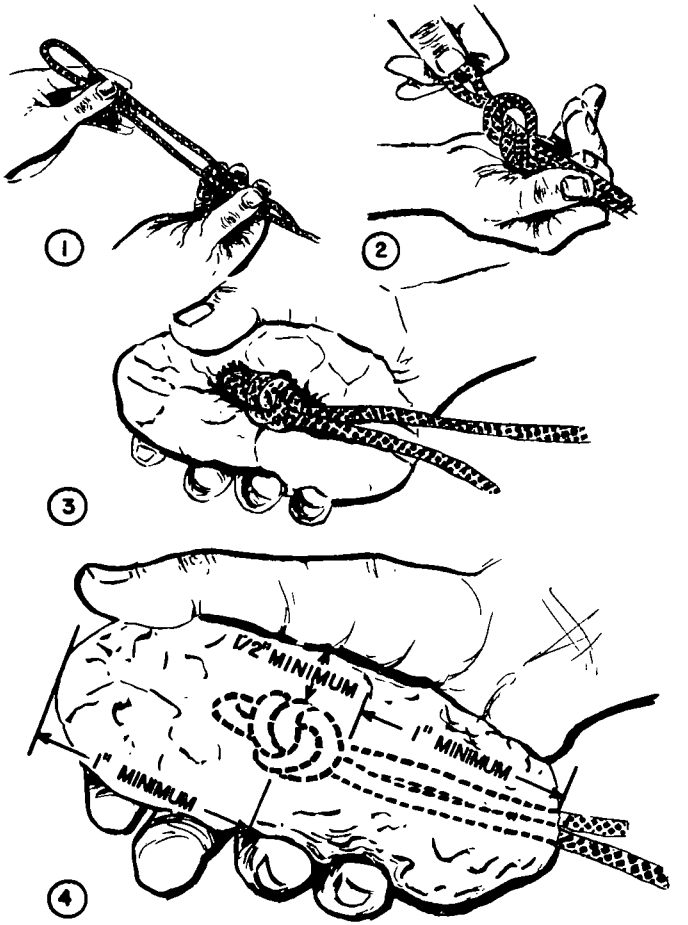


Figure 111. Priming plastic explosive with detonating cord.

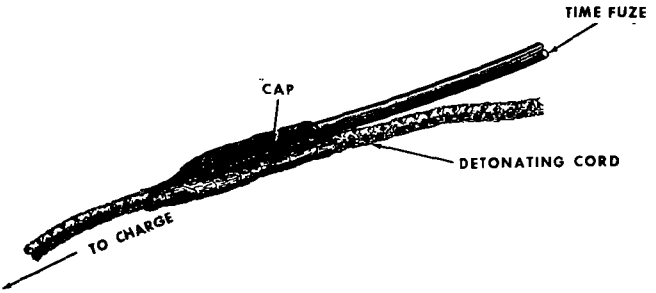


Figure 112. Fastening blasting cap to detonating cord.

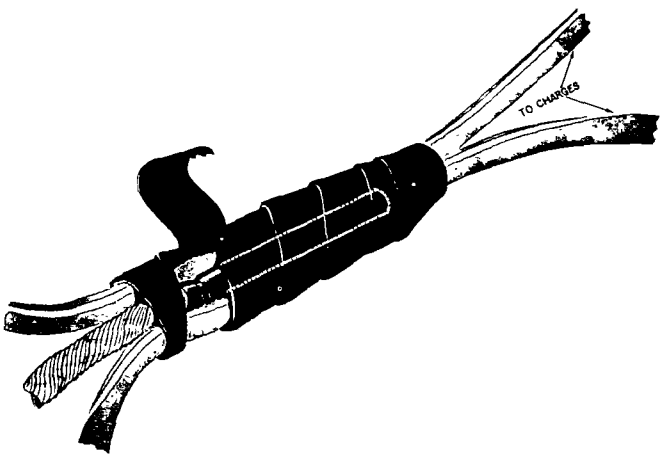


***Figure** 113. Fastening blasting cap to two lines of detonating cord.*

where and how they are to be placed. Failure to use the right amount of explosive or improper placing of charges can result in failure of the demolition project. The following will aid you in placing charges properly on concrete, steel, and timber.

a. Hasty Road Crater. Figure 114 shows the placement of charges for a hasty road crater. This method produces a crater about 1½ times deeper and 5 times wider than the depth of the boreholes, and about 16 feet longer than the line of boreholes.

b. Concrete. Because of the difficulty in placing internal charges, concrete is normally attacked by external charges calculated to blast through its entire thickness (see fig. 115). In attacking

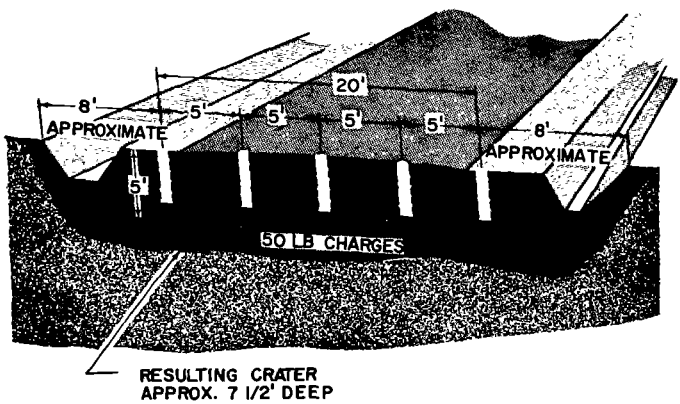


Figure 114. Placement of charges for a hasty road crater.

a concrete wall, or a bridge abutment or pier, the entire amount of explosive is normally concentrated at the midpoint of the structure, provided the width is not more than twice the thickness. Where the width is more than twice the thickness, two or more charges are used, each charge being large enough to shatter the thickness of the wall, and the distance between successive charges being not greater than twice the thickness of the structure.

c. Steel. The effects of an explosion are very localized in steel. Only that portion of steel which is in close contact with the explosive charge is cut. A concentrated charge placed on a steel plate will simply blow a hole in the plate or dent it directly under the charge. Therefore, if it is desired to cut a steel plate, the calculated charge must be distributed over the entire line along

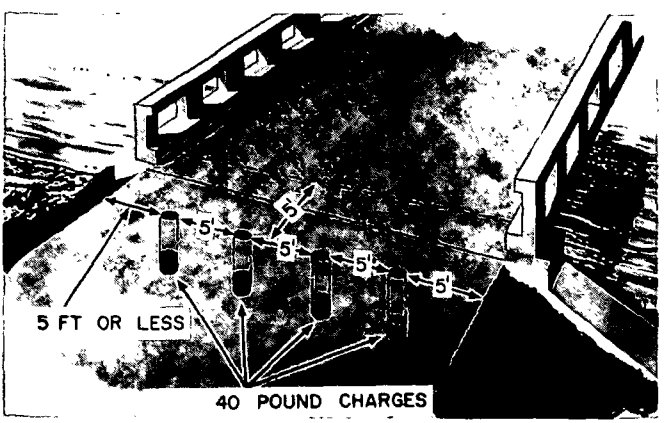


Figure 115. Placement of charges on concrete abutment.

which the cut is desired. Likewise in cutting steel I-beams, built-up girders, columns, etc., the charge must be distributed so that the entire cross section of the member will be cut (fig. 116). Charges must never be placed opposite one another on opposite sides of the steel member to be cut, but rather they should be offset between 1 and 3 inches to give a shearing effect.

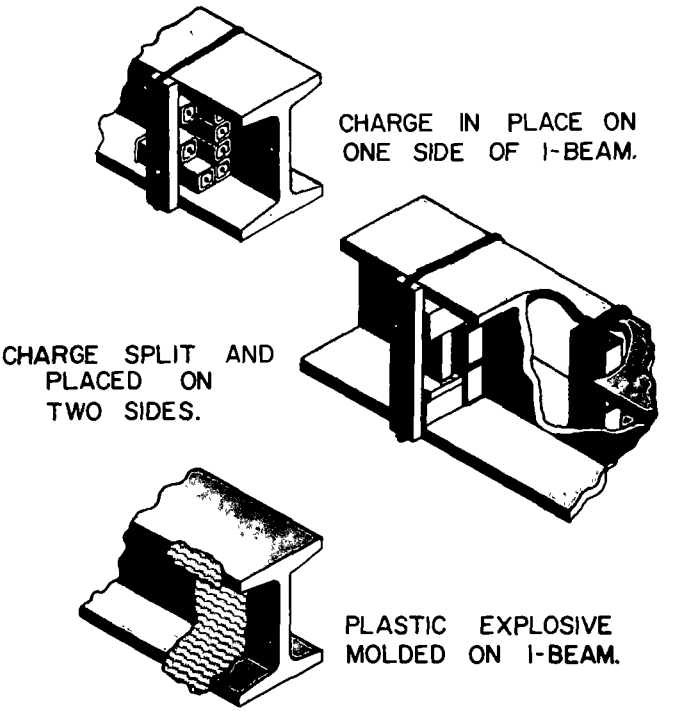


Figure 116. Placement of solid and plastic charges on steel I-beam.

d. Timber.

(1) External charges are placed as close as possible to the surface of the timber to be cut, regardless of the type of cut desired. To completely cut the timber, the explosive is placed on the widest face so that the cut will be through the least thickness. If the direction of fall is of no concern and the tree or timber concerned is approximatey circular, the explosive should encircle the object (fig. 117). When cutting trees to form an obstacle, the explosive charge should be concentrated as much as possible on the side of the tree in the desired direction of fall.

(2) Internal charges (fig. 118) are placed in boreholes parallel to the greatest dimension of timber cross section. They are tightly tamped with moist earth or clay. If the charge is too large for one borehole, two holes are bored close together at right angles and both fired simultaneously.

38. Improvised Charges

The techniques and charges presented below are not replacements for the present standard demolition methods but are recommended for use in unique and special demolition projects. The trained personnel, time, and material at hand will generally determine their use.

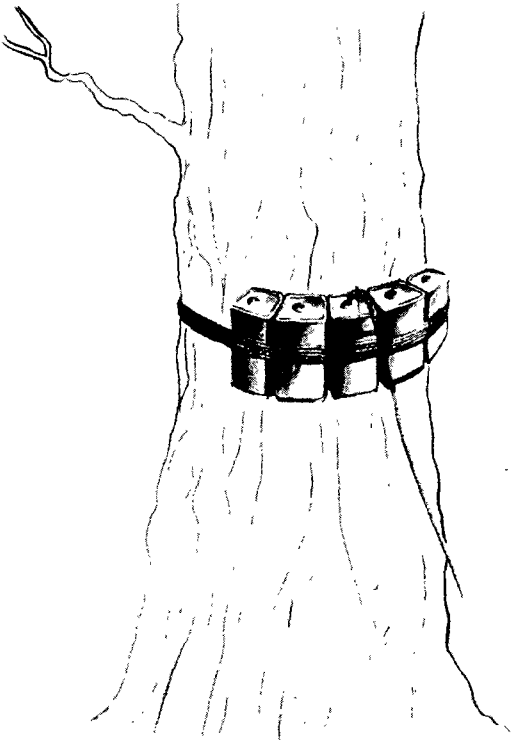


Figure 117. External charges to cut timber.

a. Steel-Cutting Charges. Three types of steel-cutting charges are used—the saddle, diamond, and ribbon charges. Their effectiveness is improved by wrapping them in aluminum foil or heavy paper provided that not more than one

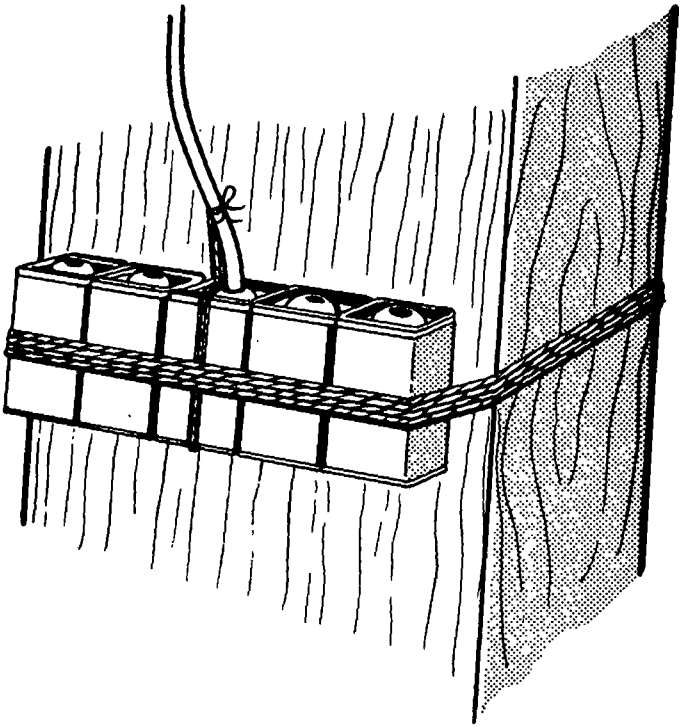


Figure 117—Continued.

thickness of the wrapper lies between the charge and the target.

(1) *Saddle charge.* This charge is used on solid cylindrical mild steel targets up to 8 inches in diameter. Detonation is

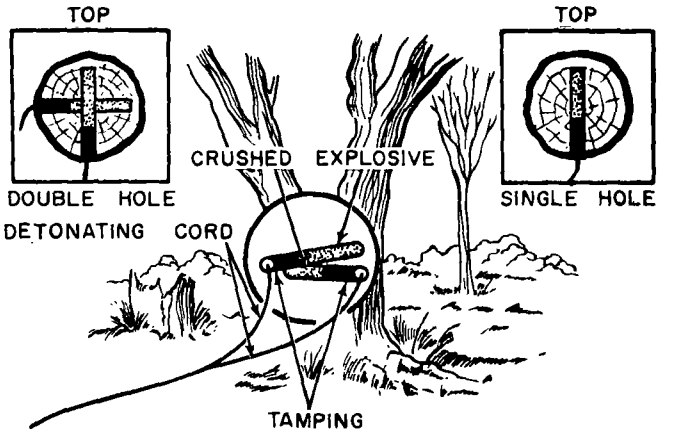


Figure 118. Internal charges to cut round timber.

initiated at the apex of the long axis (see fig. 119).

(2) *Diamond charge.* This charge is used on high carbon steel or steel alloy targets. It is diamond shaped and is wrapped completely around the target (see fig. 120) so that the ends of the long axis meet. Detonate the charges simultaneously from both short axis ends. The best means of doing this is to crimp nonelectric blasting caps to the ends of two pieces of detonating cord of the *exact same length.* The two pieces of detonating cord are detonated by an electric or nonelectric cap.

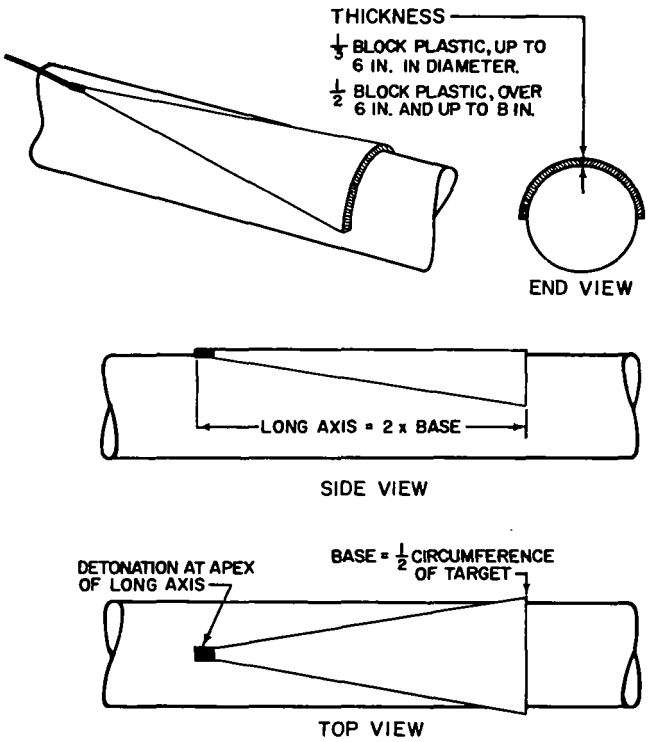


Figure 119. Saddle charge.

(3) *Ribbon charge.* This charge (fig. 121), if properly calculated and placed, cuts steel with considerably less explosive than standard charges. It is effective on noncircular steel targets up to 2 inches thick. The ribbon charge is det-

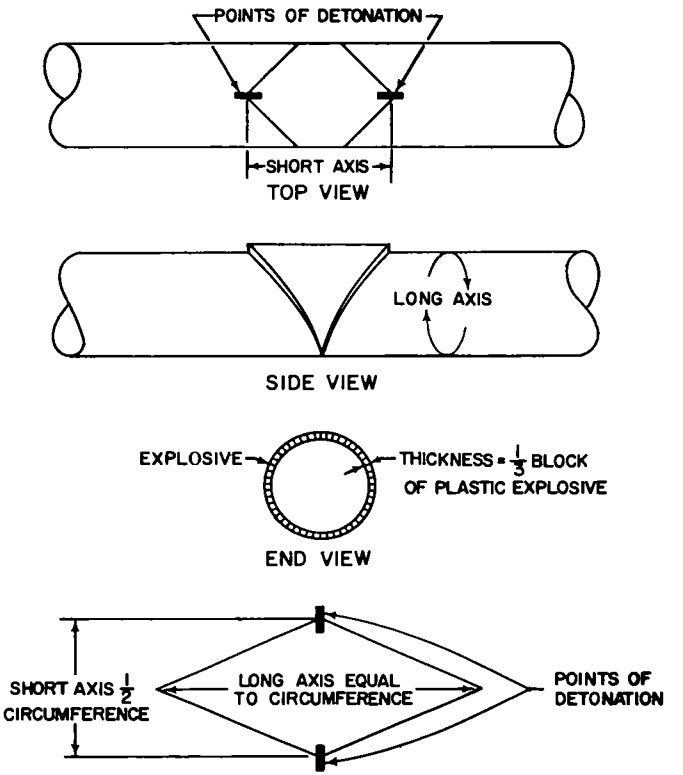


Figure 120. Diamond charge.

onated from one end only. It may be necessary, where the calculated thickness is small, to "build up" the detonating end with extra explosive. Either electric or nonelectric caps are satisfactory for detonation. The steel member

will rupture at approximately the center of the ribbon.

b. Shaped Charges. Shaped charges are easily and readily improvised. Because of the many variables, such as explosive density, configuration, and density of the cavity liner, consistent results are impossible to obtain. Thus experiment, or trial and error, is necessary to determine the optimum standoff distance. Plastic explosive is best suited for this type of charge. Almost any kind of container is usable (fig. 122). Bowls, funnels, cone-shaped glasses (champagne glasses with the stem removed), and copper, tin, zinc, or cardboard may be used as cavity liners. Bottles

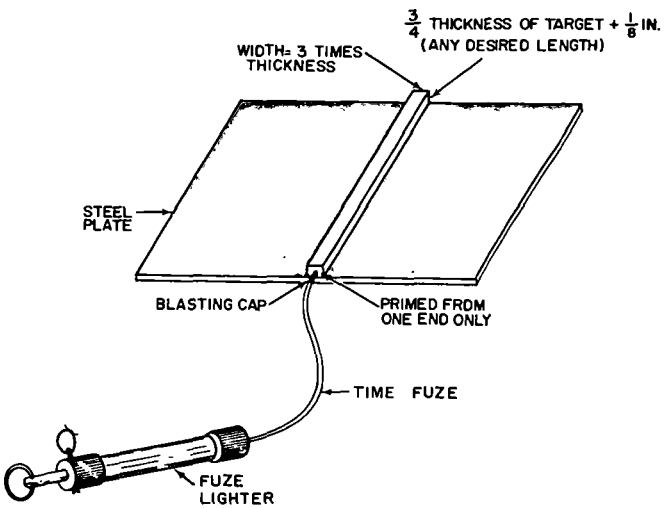


Figure 121. Ribbon charge.

with a cavity in the bottom (champagne or cognac bottles) are excellent. If none of these are available, a reduced effect is obtained by cutting or carving a cavity into the plastic explosive block.

(1) Always detonate from the exact top center.

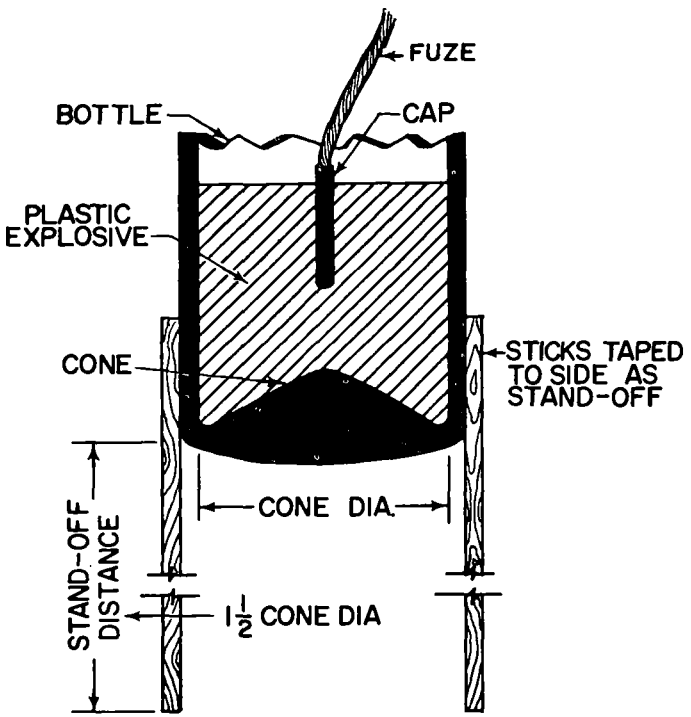


Figure 122. Improvised shaped charge.

(2) Make the angle of the cavity (cone) between 30° and 60°.

(3) Be sure the standoff distance is 1 to 1½ times the diameter of the cone.

(4) Be sure that the height of the explosive in the container is 2 times that of the cone, measured from the base to the top.

Note. The narrow necks of bottles or the stems of glasses may be cut by wrapping them with a piece of soft, absorbent-type twine or string soaked in gasoline and lighting it. After the twine has burned, submerge glass in water and break it off.

39. Field Expedient Flame Devices

Flame field expedients include flame land mines, flame fougasses, and flame illuminators. The flame expedients discussed below have been used effectively in combat. Variations and adaptions of these basic field expedients to meet specific combat situations are limited only by the imagination and initiative. Technical details on their construction are published in TM 3–300.

a. Flame Land Mines. The flame land mine consists of a container, an incendiary fuel (usually thickened gasoline), and a firing system to scatter and ignite the fuel. The size of the area it will cover depends on the size of the mine. It may be detonated by the M4 incendiary burster (fig. 123), or by some other available explosive used with the WP (white phosphorus) hand grenade which serves as an igniter. A 5-gallon con-

tainer will cover an area approximately 25 meters in diameter (fig. 124). A 55-gallon container will cover an area approximately 85 meters in diameter.

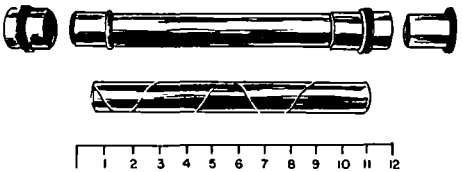
b. Flame Fougasse. The flame fougasse (fig. 125) is a variation of the flame mine in which the flame is projected by explosive means over a preselected area. The container for this form of weapon may take one of several forms. For example—

(1) A metal cylinder or 8-inch shell container, open at one end, dug in and firmly braced at an angle that will give maximum effect over the area selected. It will project flame approximately 45 meters.

(2) A 5- to 20-gallon metal container emplaced in a V-trench. Explosives placed under the container give direction to the burning fuel.

c. Flame Illuminators. A number of flame devices may be used to produce limited battlefield illumination. Such devices include—

(1) A 5- to 55-gallon drum filled with thickened fuel, tightly sealed, and set in a hole so that the top is slightly below ground (fig. 126). Coils of detonating cord are wrapped around the inside edge of the top of the drum. The coil is tightly tamped with earth. When detonated, the cord cuts off the top of the



The M4 incendiary burster may be used with any container into which it can be inserted. One burster is sufficient for a 5-gallon container. Other bursters can be joined together to rupture larger containers. The 55-gallon drum requires 2 or 3 bursters. The incendiary bursters or bursting charge should be placed so as to throw the flame fuel up and out.

Figure 123. Incendiary burster, M4.

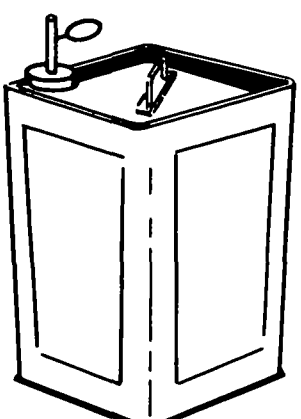


Figure 124. 5-gallon land mine.

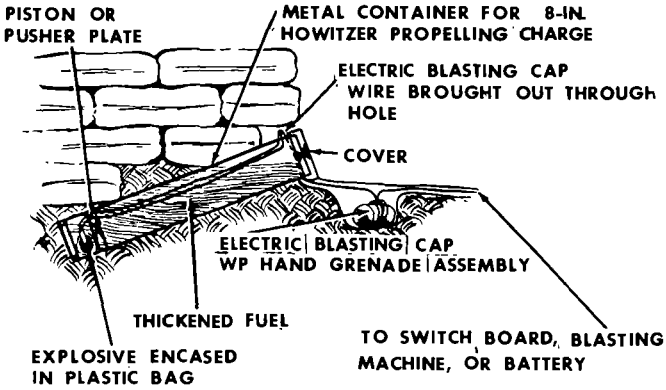


Figure 125. A flame fougasse.

drum and a white phosphorus grenade which has had its handle taped, safety pin removed, and placed on top of the drum ignites the fuel. This type of device will burn for several hours and cannot be easily extinguished with equipment normally available to attacking enemy troops.

(2) The Husch flare (fig. 127) is a device constructed from metal containers, thickened fuel, and a white phosphorus grenade. It provides illumination over an area approximately 90 meters in diameter for about 1 hour.

d. Molotov Cocktail. A molotov cocktail is an improvised incendiary grenade made from a flammable liquid mixed with sawdust or other similar type thickener contained in a glass bottle. A wick is inserted in the neck of the bottle and

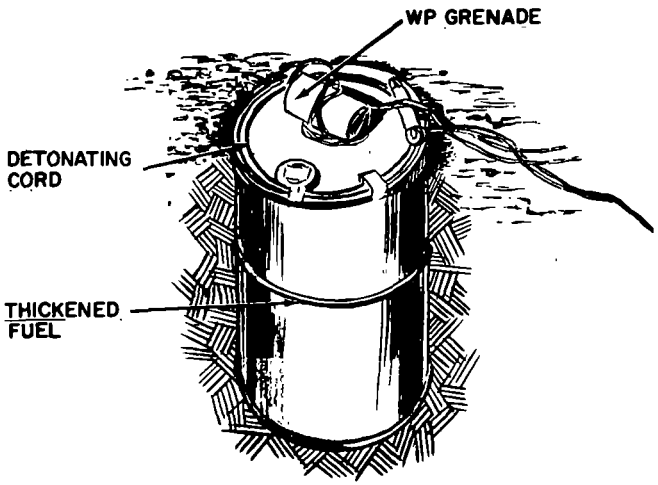


Figure 126. Flame illuminator.

ignited by a match or some other type of flame producing device and the grenade thrown at the target. The bottle breaks upon contact with the target, spilling flaming liquid over the target. This device is particularly effective against armored vehicles.

40. Safety Precautions

a. Do not smoke while handling explosives, nor handle explosives near open lights, fires, or stoves.

b. Do not handle or keep explosives in or near places where there are large groups of people.

c. Do not leave explosives in the open where they may be stolen, tripped over, or where animals can get at them.

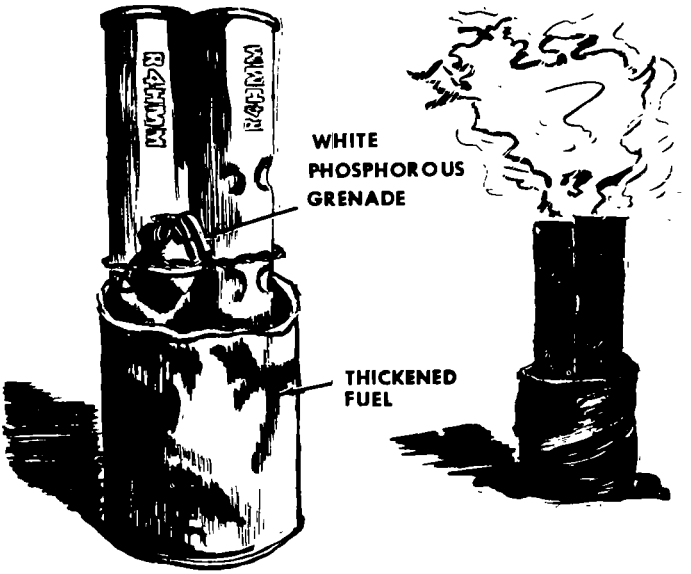


Figure 127. The Husch flare.

d. Do not leave exposives in wet or damp places; keep them locked in a dry place.

e. Do not keep or transport caps anywhere near explosives.

f. Do not carry caps in your pockets; keep them in their box until time to use.

g. Do not pull on wires of an electric cap.

h. Do not crimp caps with anything except issue cap crimpers.

i. Do not tamp with iron or steel bars or tools; use only a blunt wooden tamping stick.

j. Do not force primer into drill hole; **make** hole big enough.

k. Do not cut fuze too short; explosion may occur before safe distance can be gained. Test the burring rate of time fuze before use.

l. Do not risk a misfire by using a wrong size cap; employ proper cap for explosive used.

m. Do not explode charge until everyone is safely under cover or out of danger.

n. Do not connect firing wires to exploder until ready to fire charge.

o. Do not spring (enlarge) borehole and then immediately reload; the borehole will still be hot and may explode charge.

p. Do not forget that explosives are *always* dangerous.

q. Do not use old, leaking, or frozen dynamite.

r. Do not leave explosives or caps exposed to direct sunlight.

s. Do not prime or connect charges for electric firing during a thunderstorm.

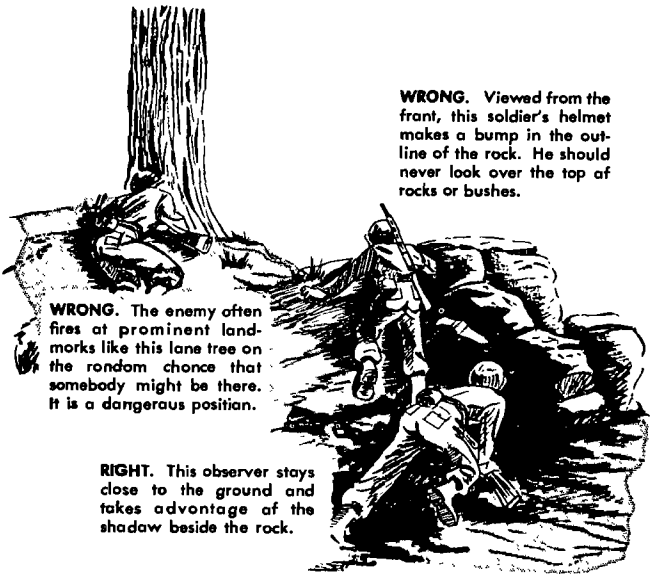
t. Do not use an electric firing system within range of a power transmitter as stated in AR 385–63.

u. Do not use any battery except BA 245/V in the galvanometer.

v. Do not make sharp bends or twist time fuse and detonating cord.

w. Do not fire a charge until everyone is out of danger. Post guards to prevent persons from approaching the danger area.

x. Do not investigate a nonelectric misfire until 30 minutes past the expected time of detonation.



SKYLINE SILHOUETTE. Night or day, there is no camouflage known to man which blends perfectly with the sky. Camouflage is worthless if worn by a soldier silhouetted against the skyline.

Beware of hills. A soldier standing below the crest may, nevertheless, appear to be on the skyline to an enemy observer at the base of the hill. The skyline varies according to the angle from which a hillside is viewed.

Figure 128. Relative positions.

CHAPTER 5

CAMOUFLAGE

41. Basic Considerations

Camouflage is the technique of concealing or disguising military activities and personnel. It is used to gain the element of surprise and to reduce personnel casualties and destruction of equipment by enemy actions. Camouflage permits you to observe the enemy without being seen, to move without being detected, and to give the impression of being in a position or location which is not really occupied.

42. Factors of Recognition

Factors of recognition are signs that will determine how quickly an individual or activity will be detected, observed, and recognized. These factors are relative position, shape, shadow, texture, color, and movement. All factors must be considered to insure effective camouflage. Relative positions are illustrated in figure 128 and shape characteristics are shown in figure 129.

a. Shadow. Shadows may reveal or they may conceal as shown in figure 130.

b. Texture. Texture describes the characteristics of a surface. Highly textured surfaces ap-

pear dark (fig. 131) and remain constant in tone regardless of the direction of view and lighting, whereas *smooth* surfaces change from dark to light with a change in lighting or direction of viewing.

c. Color. Color is an aid to the observer when there is contrast between the color of an object and its background. The greater the contrast in color, the more visible the object appears. Care-

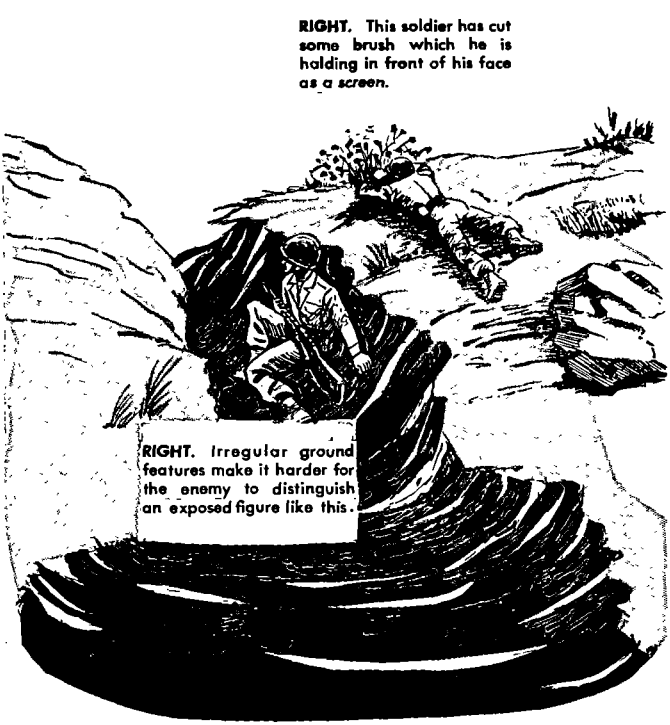
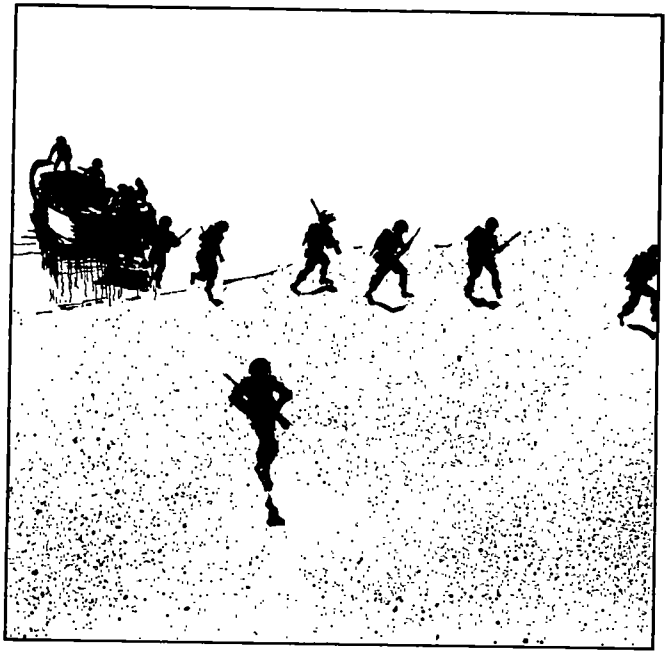


Figure 128—Continued.



SHAPE

Shape is the outward or visible form of an object or person as distinguished from its surface characteristics and color. Shape refers to outline or form. At a distance the form or outline of objects can be recognized before the observer can make out the details of their appearance. For this reason camouflage has much to do with concealing shape.

Figure 129. Shape.

ful attention must be given to the selection of the background in order to avoid definite contrasts.

d. Skin Tonedown. The uniform is designed to be as inconspicuous as possible under most conditions. There will be occasions, however, when the uniform color must be altered to blend with

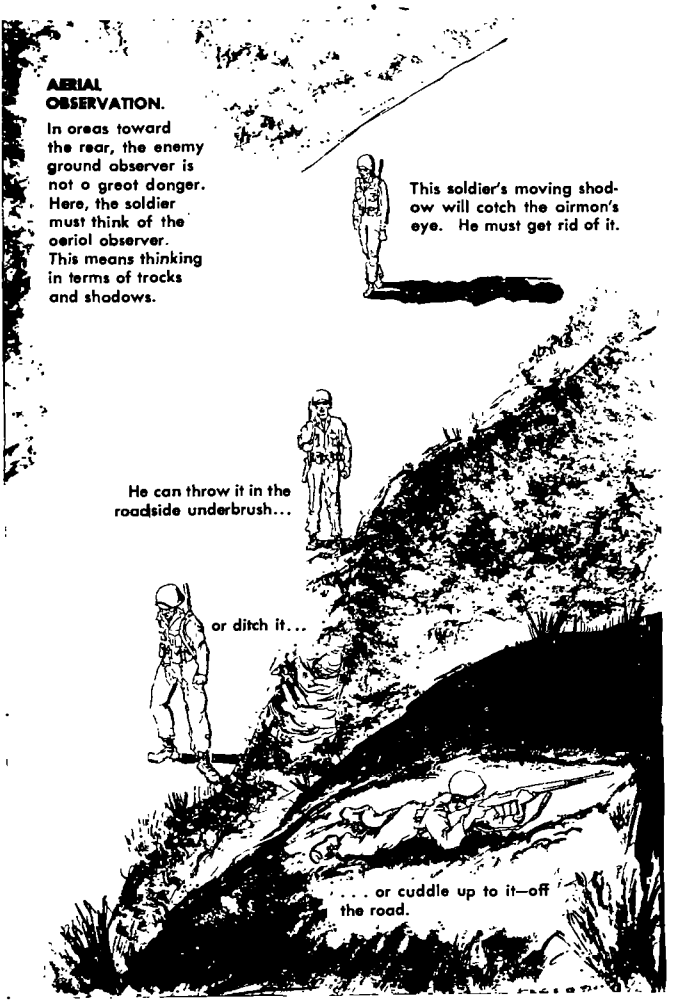


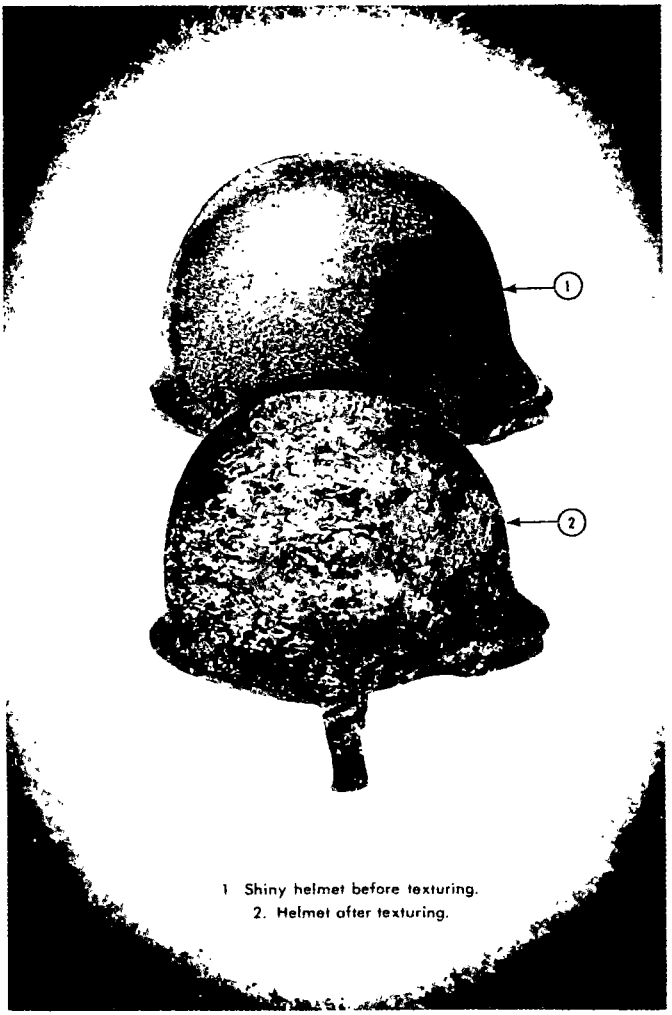
Figure 130. Shadows.

WRONG. The soldier must watch his background for lights and shadows. He can be outlined against a contrasting background as plainly as against the sky. This soldier, standing in the shade, is plainly outlined by the brightly lighted background.

WRONG. This soldier, bathed in sunlight, stands out against the shady background. Two steps backward and the shadows would fall over his figure, blending it with the speckled light and shade pattern of the jungle.

RIGHT. This soldier has become part of the background by using light and shadow patterns.

Figure 130—Continued.



1 Shiny helmet before texturing.
2. Helmet after texturing.

Figure 131. Texture.

a specific background. The color of the skin must receive individual attention and be toned to blend with the background (fig. 132). The contrast in tone between the skin of the face and hands and of the surrounding background must be reduced. The skin is made lighter or darker, as the case may be, to blend with the surrounding natural tones. The shine areas are the forehead, the cheekbones, nose, and chin. These areas should have a dark color. The shadow areas such as around the eyes, under the nose and under the chin should have a light color. The hands, arms, and any other exposed areas of skin must be toned down. Whenever the issue face paint stick is not available, burnt cork, charcoal, lampblack, and mud can be used as effective toning aids.

e. Movement. Movement (fig. 133) is the strongest factor in attracting attention. The eye is very quick to detect any movement in an otherwise still scene. Routes for movement must be chosen carefully, whether by day or by night.

43. Individual Camouflage

Individual camouflage (fig. 134) requires understanding of the factors of recognition, a knowledge of both natural and artificial camouflage materials, and ingenuity in applying these under various conditions.

44. Use of Natural Materials

Natural camouflage materials consist of that which is predominant in any particular environment. Foliage, grass, rocks, earth, debris, and

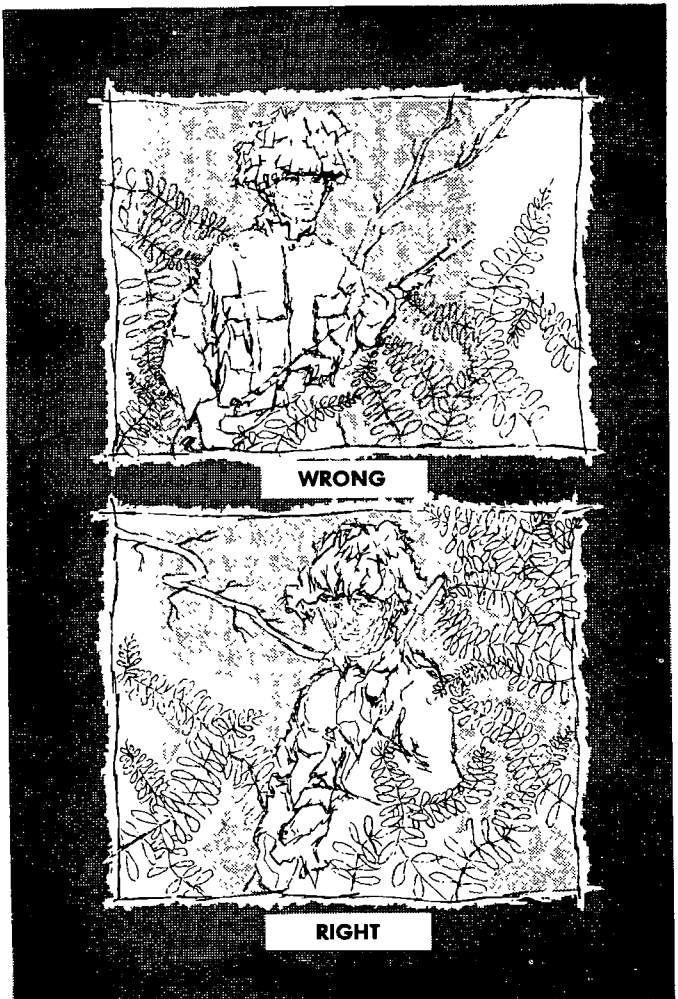
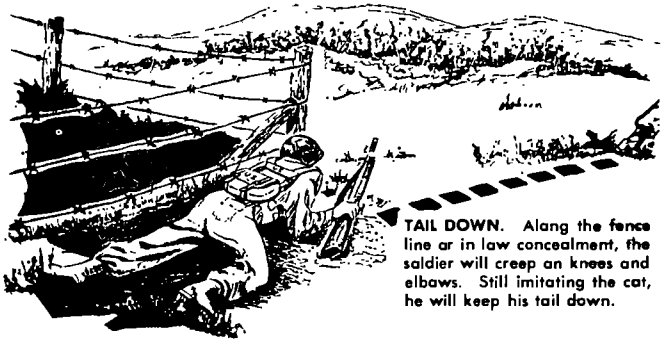


Figure 132. Skin tonedown.

IMITATING THE CAT. It will pay to study the movements of a cat stalking a bird. He wears no camouflage and he uses no tricks. He depends upon stealth alone. In moving through dangerous areas, the soldier must imitate him.



TAIL DOWN. Along the fence line or in low concealment, the soldier will creep on knees and elbows. Still imitating the cat, he will keep his tail down.

HIT THE GROUND AND ROLL. When the soldier hits the ground after a dash through the open, it is often a good precaution to roll. A hostile observer may have spotted him while he was exposed. If this is the case, bullets will soon hum through his concealment at the point where he disappeared.

Figure 133. Movement.

rubble are typical natural camouflage materials. Proper use of these materials enhances concealment, is more economical since it is readily available, and can be employed with more speed and less effort than artificial materials. One main disadvantage of using cut foliage as a natural camouflage material is that it wilts and must be replaced periodically.

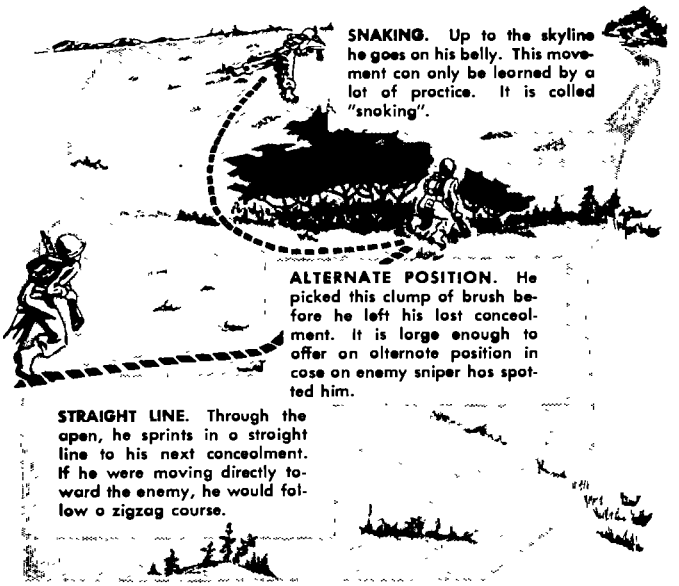


Figure 133—Continued.

45. Points to Remember

The following points are basic to good individual camouflage. As such, they should be followed at all times and used as a checklist to determine the completeness of individual camouflage.

FIND THE SOLDIER. He is standing in the open, free to move in ony direction. Too lote! Thot comouflage rifle went off while you were looking for him. This soldier went through no involved ond mysterious procedure in comouflaging himself. He simply followed the steps which we hove been discussing. Now he is no longer o torget. He is o hidden donger, reody to strike from the security of his ombush. To the weopon which he corries, there hos been odded the most deodly of oll weopons, SURPRISE.

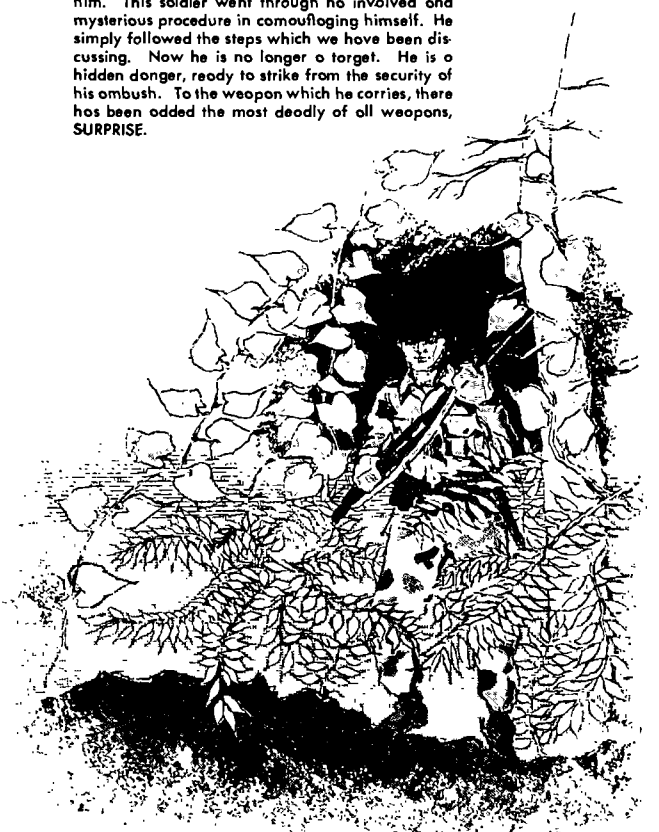


Figure 134. Individual camouflage.

a. In order for concealment to be effective, it must be protected from hostile ground or air observation.

b. Use natural terrain lines for the advance whenever possible.

c. Use varying speeds in moving quickly across open areas, slowly along natural lines of concealment, and alternately fast and slow across neutrally colored areas.

d. Observe the area in front carefully from the concealment of low bushes; look through or under them, not over.

e. Use every possible feature of the terrain for concealment.

f. Locate a place in which observation to the front is possible; a good field of view is important.

g. Locate the next stopping point and determine the best route to it before starting out.

h. Avoid a silhouette against the sky. When it is necessary to cross the skyline at a high point in the terrain, crawl to it and approach the crest slowly, using all natural concealment possible. How the skyline is to be crossed depends on whether it is likely that the skyline at that point is under hostile observation. When a choice of position is possible, cross the skyline at a point of irregular shapes such as rocks, debris, bushes, or fencelines.

i. Make every effort to reduce tone contrast and eliminate shine. Generally speaking, these

are the two features which set the individual off from his surroundings: the shine of his equipment and the difference in tone between his skin and the background. This is especially true at night.

j. Choose a position with easy access to and from a point of advantage for the individual or the unit. The appearance of the place must remain as unchanged as possible. Every bush, shrub, tree, and pile of debris must be occupied in such a manner as to leave it undistrubed. Changes in pattern and motion in parts of a normally static landscape are attention-calling signals to the trained observer. The individual must come and go without advertising his presence. When leaving a stopping point, it should be left as it was before, without signs of former occupancy.

1. EMPLACEMENT— A POSITION FROM WHICH AN INDIVIDUAL OR CREW-SERVED WEAPON MAY EXECUTE A FIRE MISSION.

2. SHELTER — NATURAL OR ARTIFICIAL PROVIDING PROTECTION FOR TROOPS SUPPLIES AND EQUIPMENT FROM EITHER ENEMY ACTION OR WEATHER.

Figure 135. Emplacements and shelters.

CHAPTER 6

FIELD FORTIFICATIONS

46. Construction and Use

Field fortifications (fig. 135) are temporary emplacements or shelters which provide protection from nuclear and conventional fires. They are constructed and used by all arms and services.

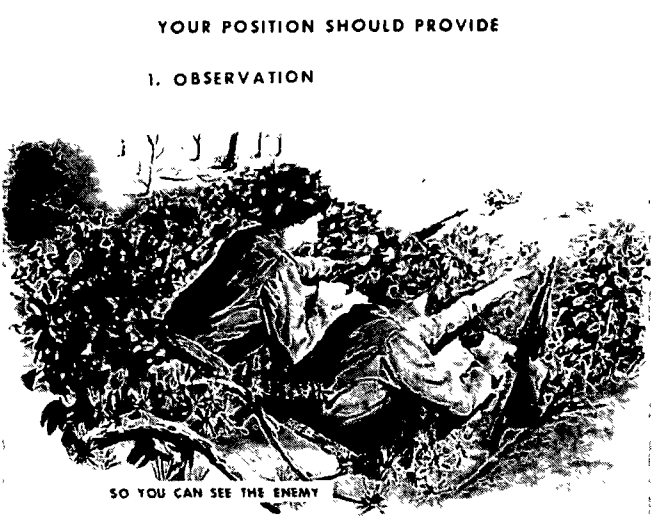


Figure 136. Characteristics of a good position.

Figure 136—Continued.

Engineer troops frequently assist in the construction of fortifications and in some instances may be entirely responsible for all fortifications in specified areas. Some of the characteristics of a good fortification position are shown in figure 136. Complete information on field fortifications is contained in FM 5–15.

47. Individual Emplacements

Protection of personnel against the effects of coventional weapons effects can best be provided by the use of individual emplacements as de-

3. COVER AND CONCEALMENT

TO PROTECT YOU FROM ENEMY FIRE AND DETECTION

4. OBSTACLES

TO STOP, DELAY, OR DIVERT ENEMY MOVEMENT

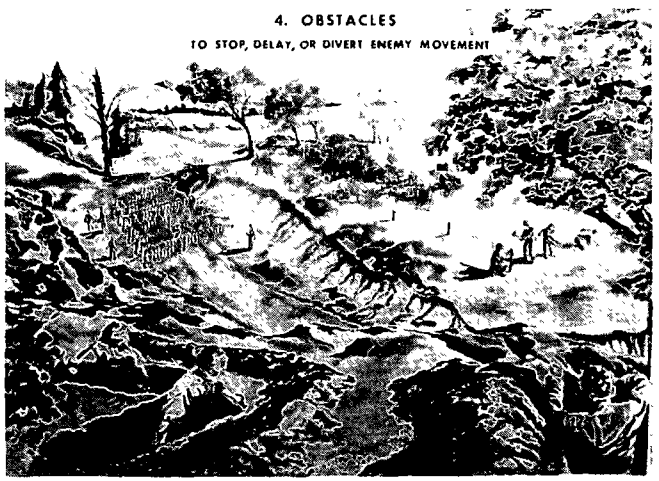


Figure 136—Continued.

scribed in figures 137 through 140. Protection against these weapons also affords some protection against nuclear weapons. A properly covered emplacement provides better protection than an open one.

48. Weapons Emplacements

Protection of crew served weapons and their crews is best accomplished through the use of weapons emplacements which in addition to affording protection also permit maximum effective use of the weapon. These emplacements are illustrated in figures 141 and 142.

5. COMMUNICATIONS

SO YOU CAN GET IN AND OUT OF YOUR POSITION WITHOUT EXPOSING YOURSELF

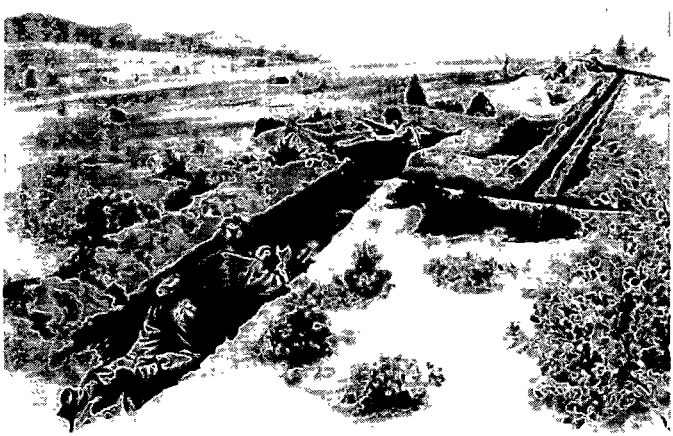


Figure 136—Continued.

Figure 137. Skirmisher's trench.

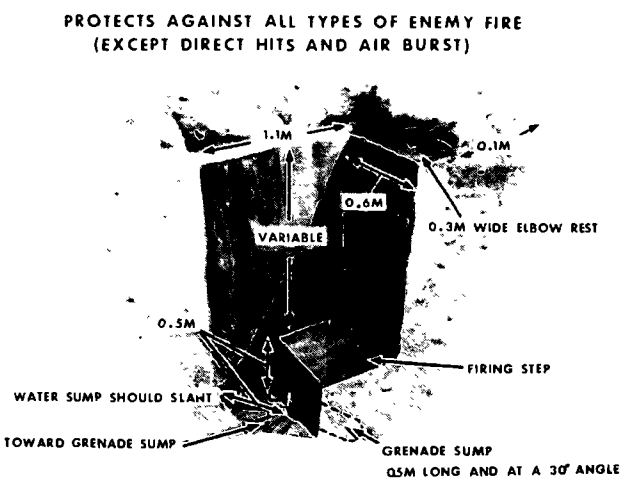


Figure 138. One-man foxhole.

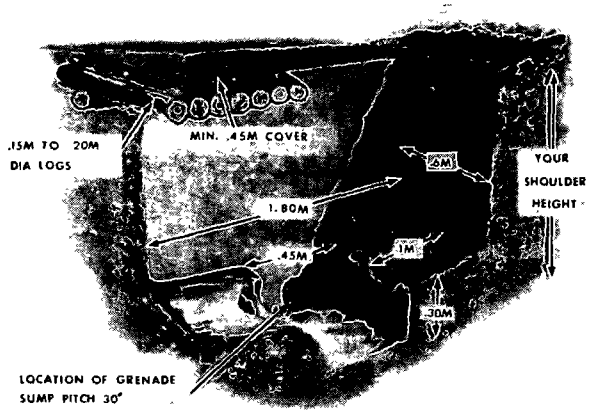


Figure 139. Two-man foxhole with overhead cover.

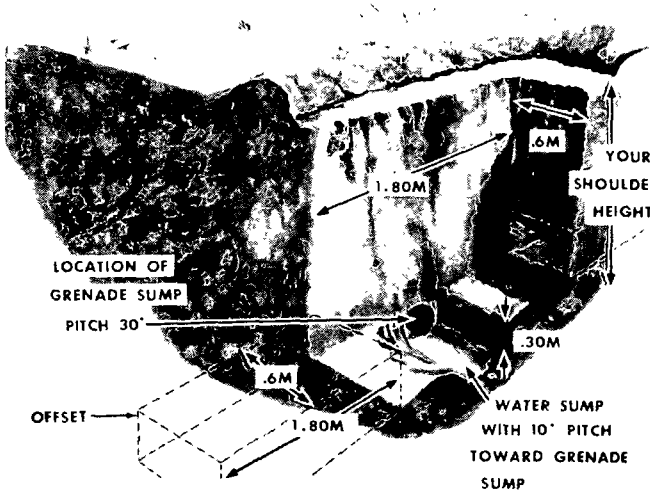


Figure 140. Two-man foxhole with offset.

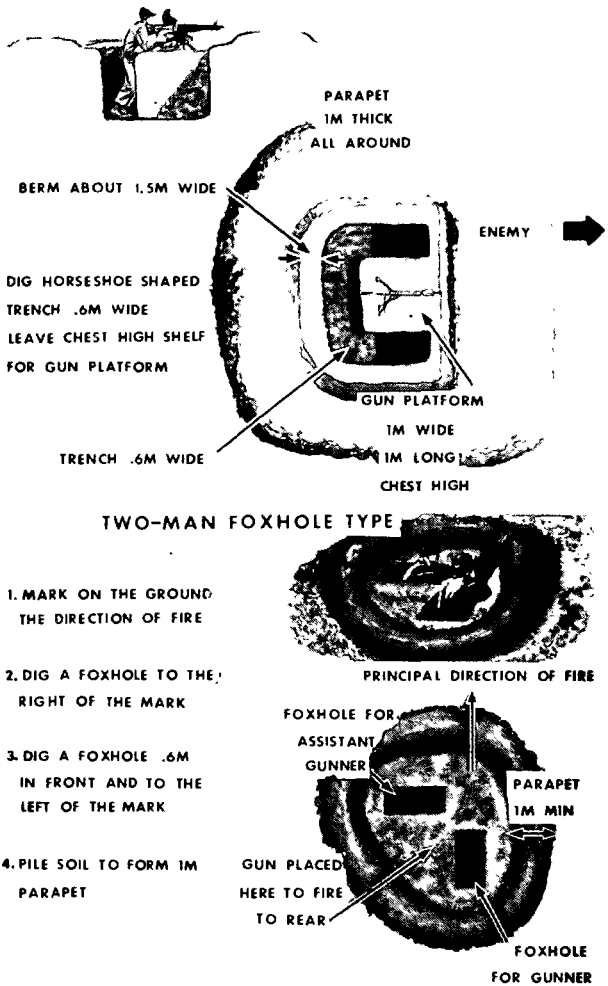


Figure 141. Machinegun position.

49. Maintenance

Weapons effects frequently damage emplacements and shelters. Consequently, this damage must be repaired and the shelters improved whenever possible. Figure 143 illustrates methods of reinforcing and improving the basic emplacements.

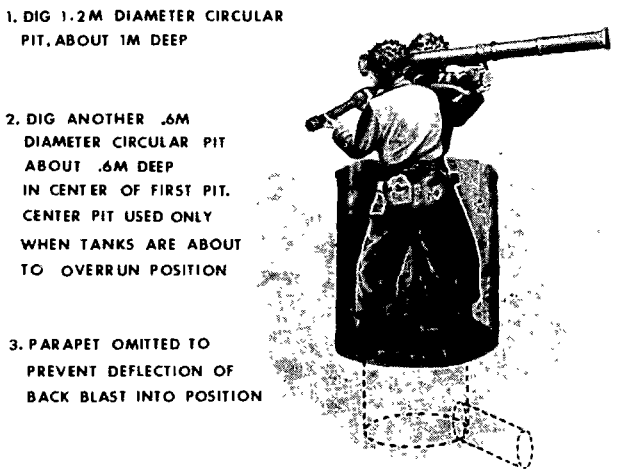


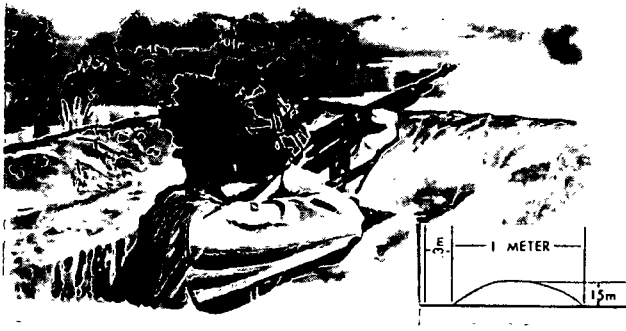
Figure 142. Rocket launcher position (pit type).

1. PARAPETS SHOULD BE ADDED TO:

A. GIVE A FIRM BASE FOR HOLDING WEAPONS

B. DIVERT SURFACE WATER

C. GIVE PROTECTION AGAINST ENEMY SMALL ARMS FIRE



2. SUMPS SHOULD BE ADDED TO:

A. DISPOSE OF GRENADES

B. COLLECT SUBSURFACE WATER

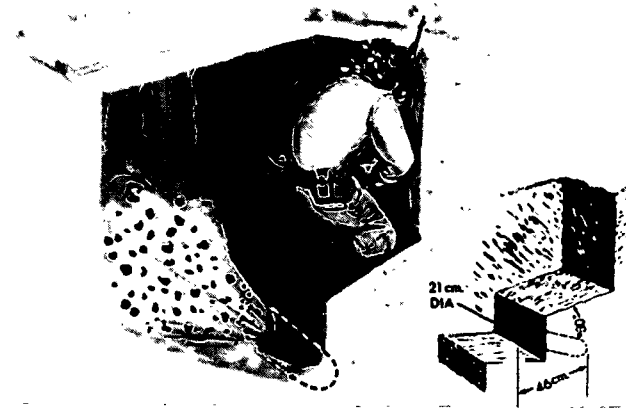


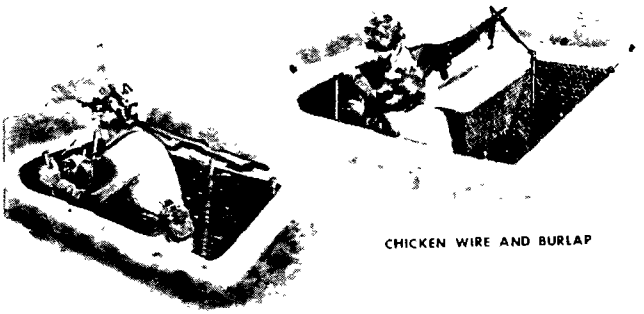
Figure 143. Common construction details.

3. SURFACE OR FACING REVETMENT

SHOULD BE ADDED TO PROTECT AGAINST—

A. BLAST AND EARTH SHOCK FROM EXPLOSIONS

B. WEATHERING OF POSITIONS DURING EXTENDED PERIODS OF OCCUPATION



CHICKEN WIRE AND BURLAP

BRUSHWOOD

4. RETAINING WALL REVETMENT

SHOULD BE USED IN NATURALLY UNSTABLE SOIL CONDITIONS

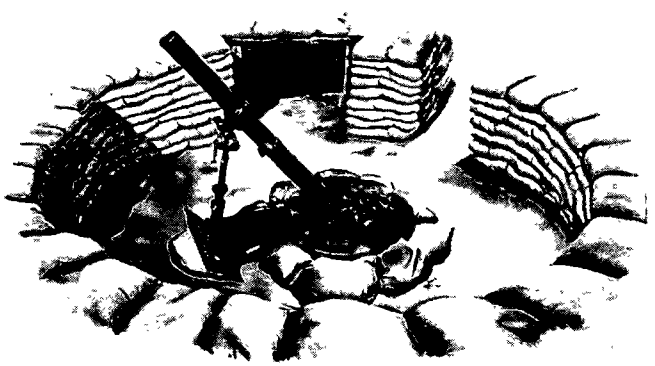


Figure 143—Continued.

5. CHICKEN WIRE CAN BE USED

FOR PROTECTION AGAINST GRENADES

GRENADES THROWN INTO THE MACHINEGUN POSITIONS ARE DEFLECTED BY CHICKEN WIRE

Figure 143—Continued.

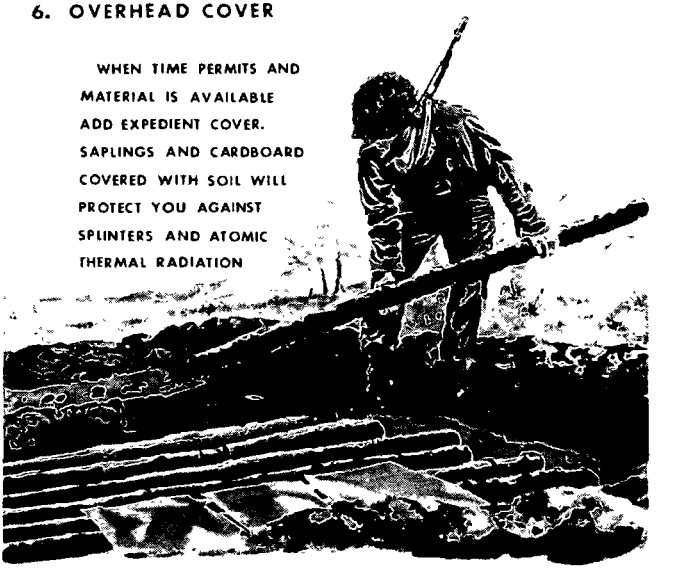


Figure 143—Continued.

CHAPTER 7

OBSTACLES

50. Introduction

An obstacle is any terrain feature or manmade object that stops, delays, or diverts movement. Obstacles play an important part in warfare. They restrict maneuver, cause delay, and require the regrouping of forces, thereby making them vulnerable to massed conventional or nuclear fires. You should become familiar with the obstacles covered in this chapter because as an engineer soldier you will be required to assist in their construction.

51. Barbed Wire Obstacles

Barbed wire obstacles are designed to impede the movement of foot troops and, in some cases, tracked and wheeled vehicles. The materials used in constructing barbed wire obstacles are relatively lightweight, portable, and rapidly and easily installed, repaired, and maintained.

a. Concertina. The standard barbed wire concertina (fig. 144) is formed by coils of barbed wire clipped together at intervals so that when the concertina is opened it is cylindrically shaped, 15 meters long and 0.9 meters in diameter. Nor-

mally four men are employed in the erection of concertina—one man on each end and the other two working along its length to insure that it opens and extends evenly. When necessary, two men can open and extend a concertina by securing one end to a picket and bouncing the roll on the ground to prevent snagging as it is extended. A series of barbed wire concertinas as shown in figure 145 will stop wheeled vehicles. When used as a roadblock, a series of these concertina rolls are placed about 10 meters apart. The ends of adjacent coils are wired together and the obstacle lightly anchored at the sides of the road. The roadblock should be sited to achieve surprise and have no bypass.

b. Double-Apron Fence. A 300-meter section of double-apron fence is a platoon task normally

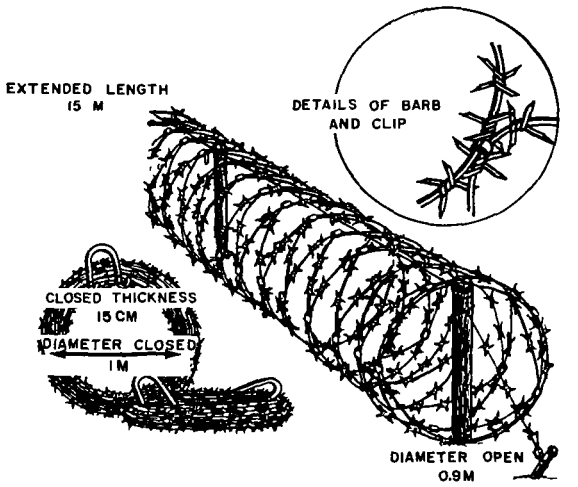


Figure 144. Standard barbed wire concertina.

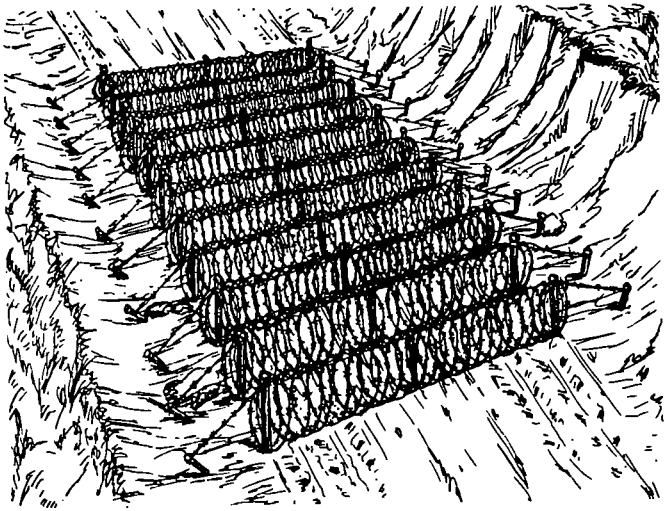


Figure 145. Concertina roadblock.

requiring 1½ hours. After layout there are two main operations in building a double-apron fence —installation of pickets and installation of wire (fig. 146). The first operation is nearly completed prior to starting the second. The second operation is started as men become available and the first operation has moved far enough ahead to avoid congestion. The order in which the wires are installed is shown in figure 146 and is further illustrated in figure 147. Care must be taken to avoid having any of the men cut off between the fence and the enemy. The men are divided into two- or four-man groups and install the wires in numerical order; that is, as soon as the men installing number 1 wire have moved away from the beginning of the fence and are out of the way, the

crew installing the number 2 wire start. Figures 148 through 151 show methods of tying barbed wire.

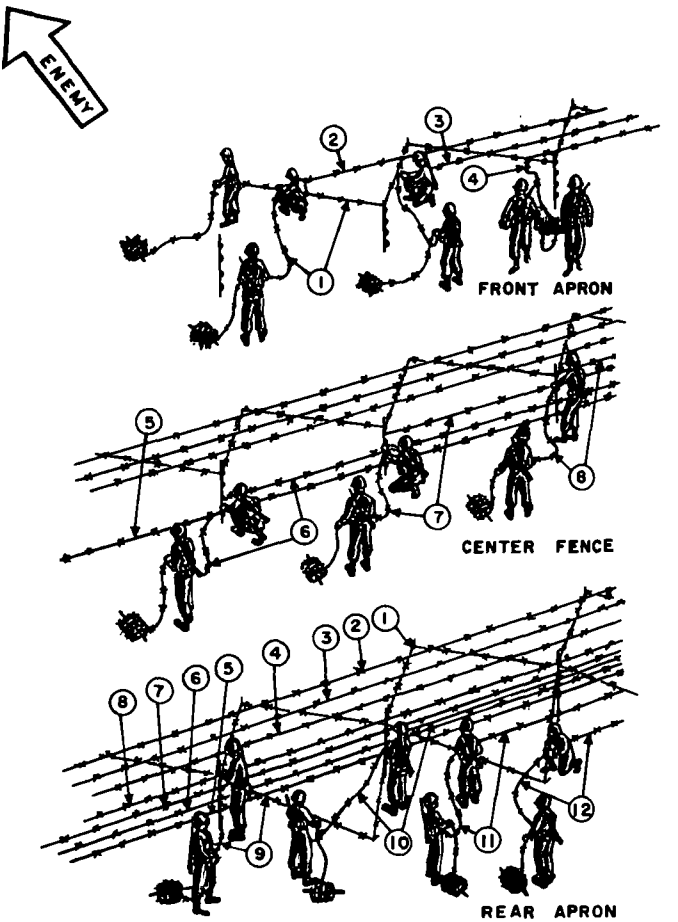


Figure 146. Sequence of installing wire in a double-apron fence.

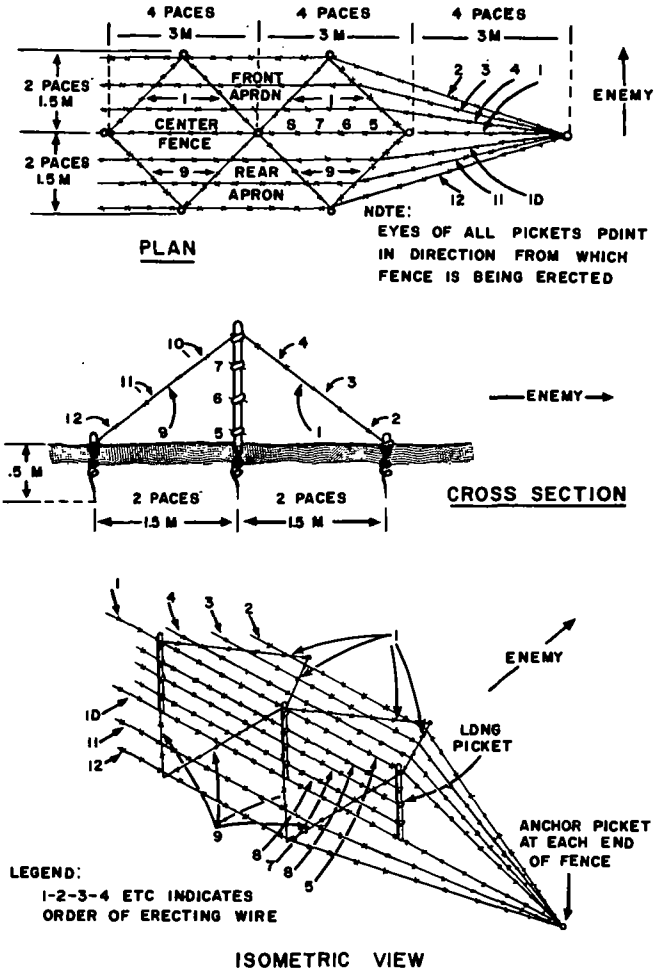


Figure 147. Double-apron fence.

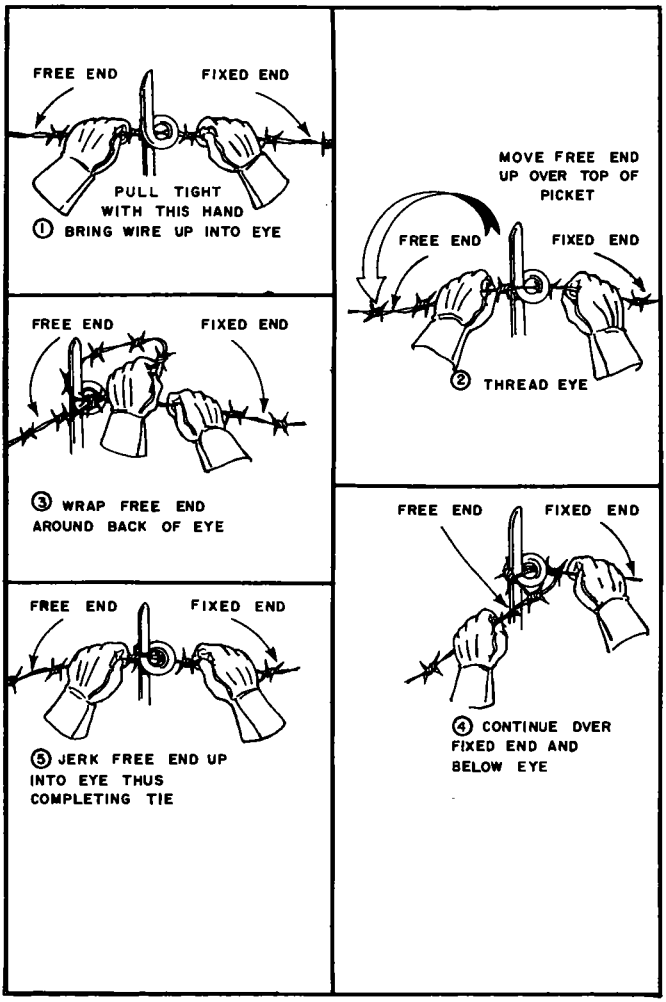


Figure 148. Top-eye tie.

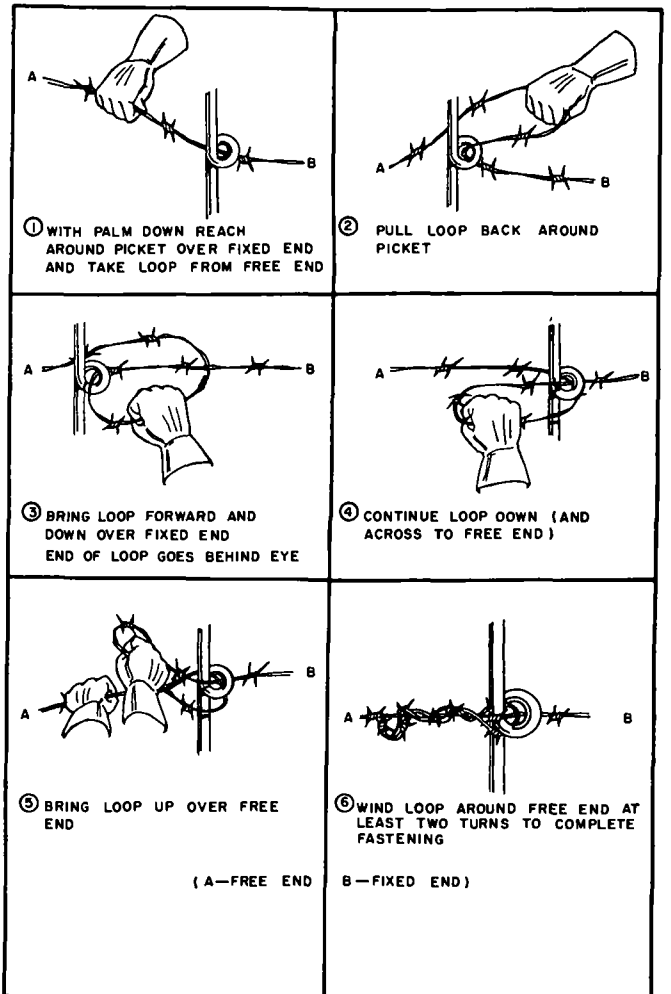


Figure 149. Intermediate-eye tie.

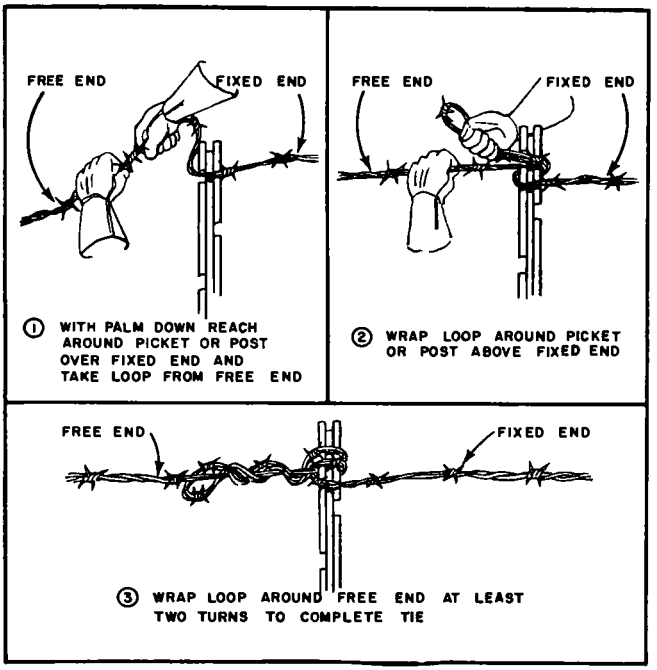


Figure 150. Post tie.

Note. Wires should be just taut enough to prevent them from being easily depressed by boards, mats, or similar objects thrown across them. If wires are stretched too tightly, they are more easily cut by fragments.

c. High Wire Entanglement. This obstacle consists of two parallel 4-strand fences with a third 4-strand fence zigzagged between them to form triangular cell (fig. 152). To add to the obstacle effect, front and rear aprons may be installed and

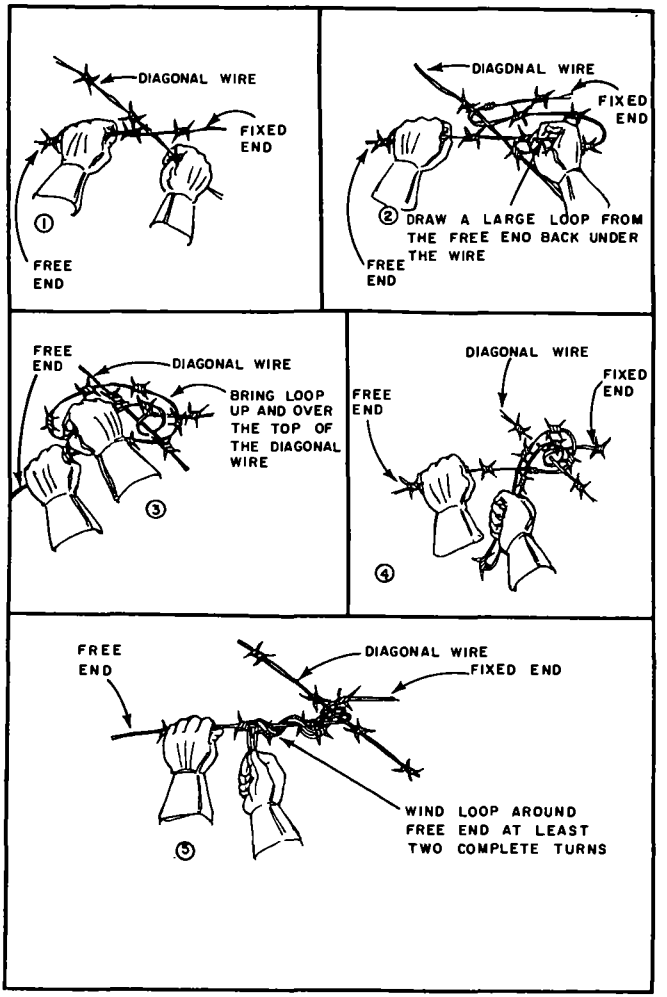


Figure 151. Apron tie.

spirals of loose wire may be placed in the triangular cells.

d. Four-Strand Cattle Fence. The 4-strand center section of a double-apron fence (fig. 153) can be installed rapidly to obtain some obstacle effect, and aprons can be added later to develop it into a double-apron fence.

e. Tanglefoot. Tanglefoot (fig. 154) is used where concealment is essential. The obstacle should be employed in a minimum depth of 10 meters. The pickets should be spaced at irregu-

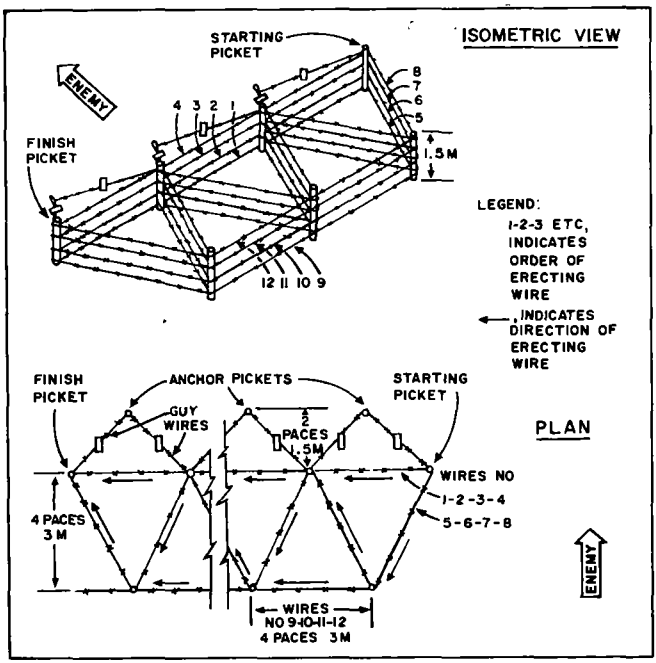


Figure 152. High wire entanglement.

Figure 153. Four-strand cattle fence.

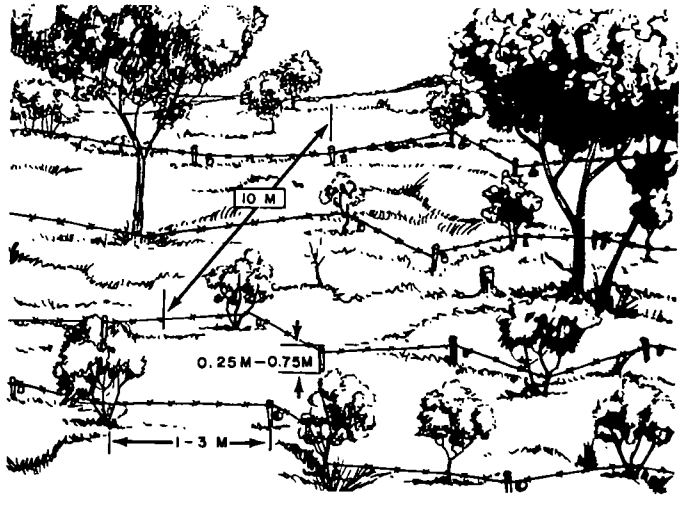


Figure 154. Tanglefoot.

lar intervals of from 1 to 3 meters, and the height of the barbed wire varies from 0.25 m to 0.75 m. It should be sited in scrub, if possible, using bushes as supports for part of the wire. In open ground, short pickets should be used.

f. Knife Rest. The knife rest (fig. 155) is a portable obstacle. It consists of a wooden or metal frame strung with barbed wire. It is used whenever a readily removable barrier is needed; for example, at lanes in wire obstacles or at roadblocks. With a metal frame it can be used as an effective underwater obstacle. Knife rests are normally constructed with 3 to 5 meters between cross members. They should be approximately 01.2 meters high. The cross members must be firmly lashed to the horizontal member with plain wire. When used as a fixed obstacle the knife rest must be secured to the ground.

g. Trestle Apron Fence. The trestle apron fence (fig. 156) has inclined crosspieces spaced 5- to 6-meter intervals to carry longitudinal wires on the enemy side. The rear ends of the crosspieces are carried on triangular timber frames which are kept from spreading by tension wires on the friendly side. The crosspieces may be laid flat on the ground for tying the longitudinal wires in place and then raised into position on the triangular frames. The frames are tied securely in place and held by tension wires. The fence should be sited in such a way that it can be guyed longitudinally to natural anchorages and pulled taut.

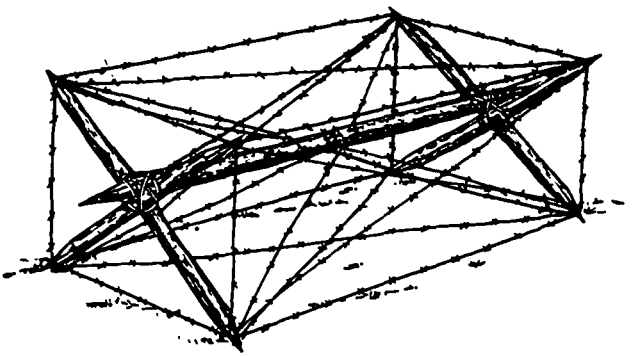


Figure 155. Knife rest.

52. Antivehicular Obstacles

Antivehicular obstacles can be natural and manmade. Examples of natural antivehicular obstacles are—heavy forested areas, deep gullies and ravines, unfordable streams, and poor soil conditions such as swamps and bogs. Manmade antivehicular obstacles include ditches, craters, log hurdles and cribs, posts, abatis, and concrete or steel structures embedded in the ground. For manmade obstacles to be effective, they should be tied into natural obstacles and covered by fire.

a. Antitank Ditches. Ditches are excavated by earthmoving equipment, by explosives as described in FM 5–25, or by handtools. To be effective, ditches made by explosives should be dressed to true surfaces by excavating equipment or handtools.

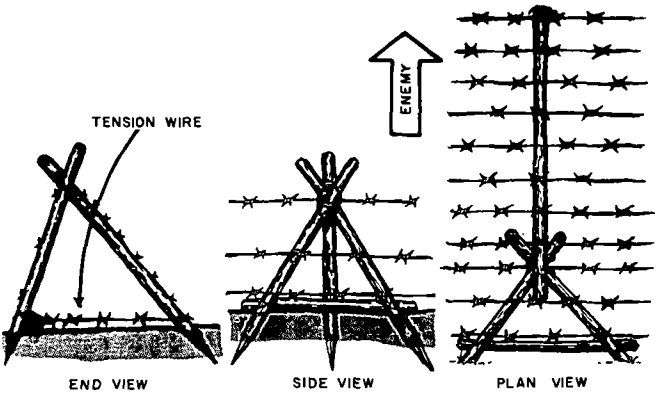


Figure 156. Trestle apron fence.

(1) *Triangular ditches* (1, fig. 157). These are relatively easy to build and will effectively delay tracked vehicles for a limted time since they can break down the slopes after repeated crossing attempts.

(2) *Sidehill cuts* (2, fig. 157). Sidehill cuts are variations of the triangular ditch adapted to sidehill locations and have the same advantages and limitations.

(3) *Trapezoidal ditches* (3, fig. 157). These require about double the construction time of triangular type ditches but are a much better obstacle. In a trapezoidal ditch as shown, the front end of the vehicle drops into the ditch as the center of gravity of the vehicles crosses the edge, and if the ditch depth exceeds the height of the vehicle wheels or treads, vehicles entering the ditch are trapped.

Sections of ditches longer than 100 meters are not normally camouflaged. In winter, a trapezoidal ditch may be camouflaged by snow to represent a standard trench (fig. 158).

b. Craters. Crater-type obstacles are used for blocking roads, trails, or defiles, at points where the terrain prevents bypassing, or where terrain that is suitable for bypassing can be mined and covered by fire. Craters should be improved wherever possible by steepening the sides, flooding, or mining. One method of preparing a hasty

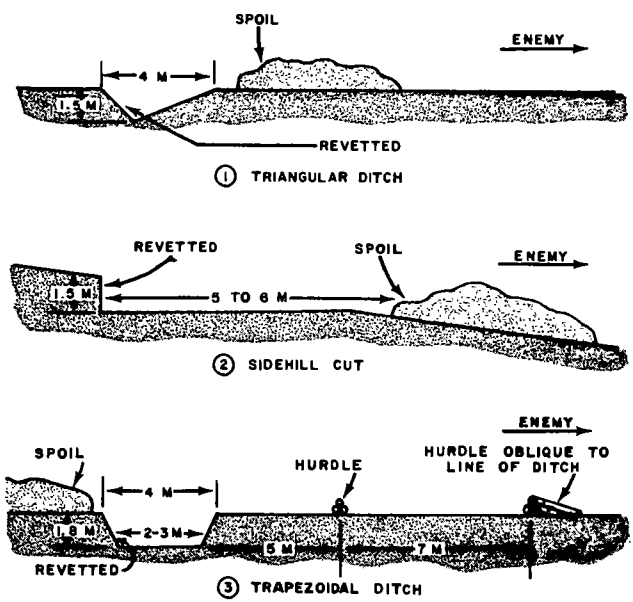


Figure 157. Types of antivehicular ditches.

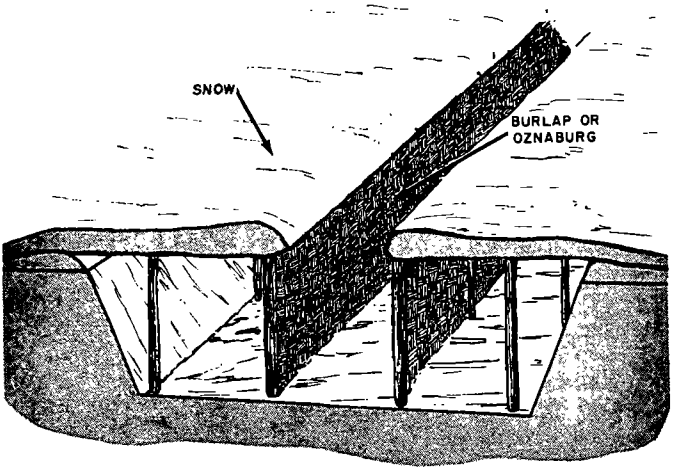


Figure 158. Antivehicular ditch camouflaged to resemble a standard trench.

road crater for demolition is discussed in paragraph 37.

c. Log Hurdles and Cribs.

(1) *Hurdles.* Log hurdles formed of 0.25 m to 0.45 m logs as shown in figure 159 may be used to add to the obstacle effect of a crater, or other type of roadblock. A hurdle of this type stops or damages most wheeled vehicles. Tanks can cross them at reduced speed on reasonably level ground but are stopped by hurdles on uphill grades which approximate the critical grade of the vehicle. The hurdle should be sited on the steepest part of

the slope (and mined) and as near the top as possible.

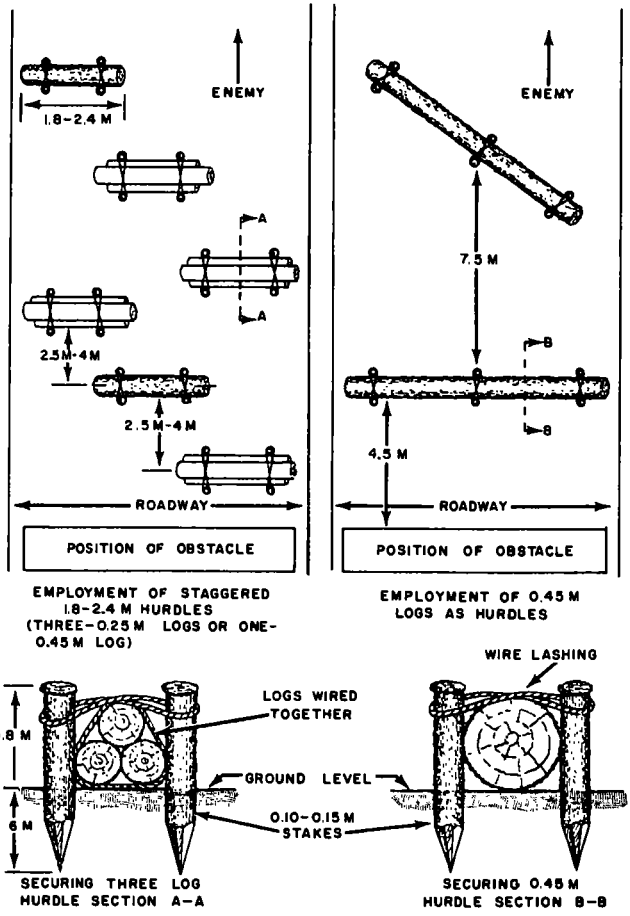


Figure 159. Types of log hurdles.

(2) *Cribs.* Rectangular or triangular log cribs (fig. 160) are used effectively as roadblocks where standing timber is available and where such an obstacle cannot readily be bypassed. Cribs are strengthened by filling them with earth; and preferably the earth is obtained by digging a shallow ditch in front of the obstacle. An engineer platoon equipped with pioneer tools can construct 6 meters of this obstacle in 4 to 8 hours.

d. Posts. Posts are effective antivehicular obstacles because each post presents a breaching problem to the attacker. Post obstacle belts may be constructed using either steel, log, or concrete posts or a combination of any of these. The effect of post-type obstacles can be enhanced and the obstacles made more difficult to breach by weaving spirals of barbed wire among the posts as shown in figure 161. The belt illustrated is an antipersonnel as well as an antivehicular obstacle and should be sited at a location which cannot be bypassed.

e. Abatis. Trees felled as shown in figure 162 can be used to block a road or defile. To stop tracked vehicles, the trees should be at least 0.6 meters in diameter and 6 meters long. To effectively block a road through a heavily wooded area, an abatis at least 75 meters deep is required. Abatis are constructed by using handtools or explosives. Bushytop trees with heavy branches and thick foliage should be used since the

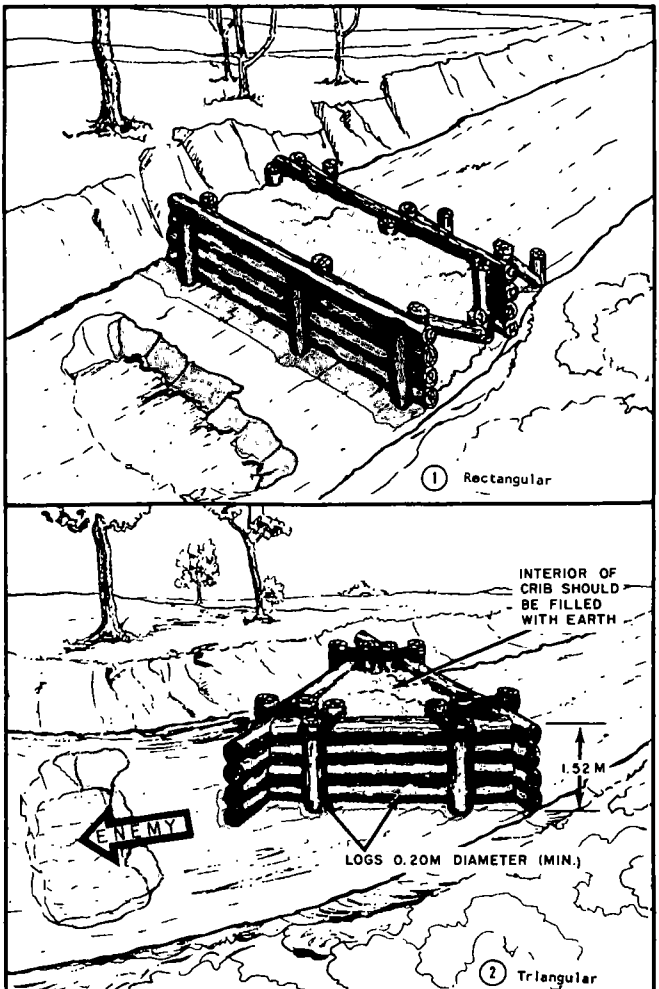


Figure 160. Log cribs.

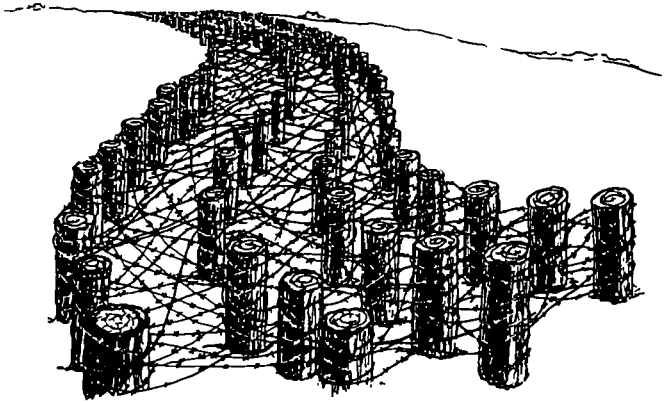


Figure 161. Belt of log post obstacles.

branches reduce the momentum of the vehicle and the foliage acts as a screen. The trees should be felled so that the trunk remains attached to the stump. The effectiveness of an abatis is increased by interlacing barbed wire in the branches of the trees and planting antipersonnel mines.

f. Oiled Roadways. A cobblestone street well coated with oil is a very effective obstacle, especially against tracked vehicles. Suitable areas would be narrow streets bordered by buildings or walls to restrict the maneuverability of the vehicle. Large areas should be coated to prevent the momentum of the vehicle from carrying it across the obstacle.

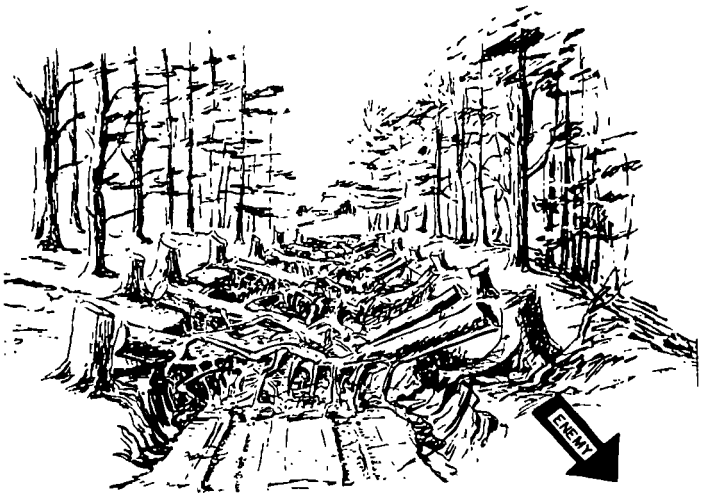


Figure 162. Abatis used as a roadblock.

53. Expedients

a. Roadblocks may be improvised from farm carts, automobiles, and trucks, railroad cars which are loaded with rock, concrete, or other heavy material. When placed in position their wheels should be damaged or removed, and the vehicles should be firmly anchored.

b. A roadblock which may be effective in some situations is constructed quickly by the method shown in figure 163. A heavy tree at one side of a road is cut almost through and a wire rope is attached to its trunk and to another tree across

the road in such a manner that if a passing vehicle strikes the rope the tree will fall and damage the truck or pin it in place.

c. Plain wires stretched across a road at a height of 1 to 2 meters will sometimes decapitate vehicle drivers. Fencing, telegraph or telephone wires may be used, stretched tight and firmly attached to trees, telephone poles, walls or fences. The wires should make an angle of between 45° and 90° to the road.

d. A good winter weather road obstacle is constructed by stretching a heavy wire rope at 45°

Figure 163. Wire-rope roadblock.

across the road at a height of about 1 meter. The rope should be located just over the top of a hill or around a blind corner on a downhill grade. Slant the wire rope to divert the vehicle over a steep embankment, into a deep ditch, or into a tree.

e. The construction of "man traps" such as camouflage pits (Panji jungle traps) with sharpened stakes in the bottom and bamboo whips (figs. 164 and 165) are obstacles that can be used effectively in areas frequented by guerrillas. Extreme care must be taken to insure that friendly troops and inhabitants do not fall victim to these devices.

Figure 164. Panji jungle trap.

Figure 165. Bamboo whip.

f. Belts of sharpened stakes or bamboo barbs imbedded in the earth closely together present a very formidable obstacle to foot troops (fig. 166). This type of obstacle should be employed in tall grassy areas.

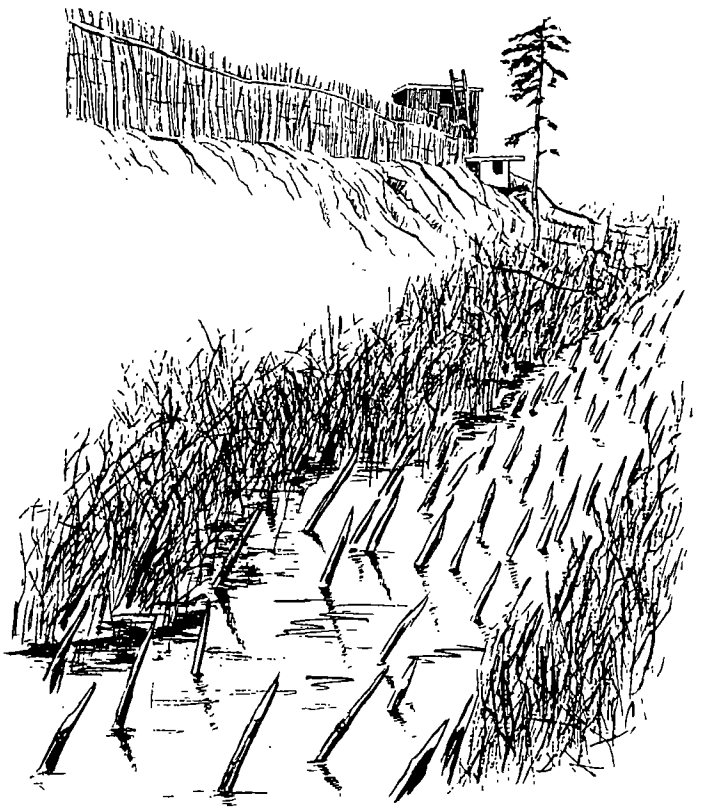


Figure 166. Belt of imbedded sharpened stakes.

CHAPTER 8

ASSAULT OF FORTIFICATIONS

54. Problems Encountered

Permanent fortifications present one of the most formidable obstacles an advancing force may encounter. The passage of these fortifications usually causes a serious delay of the advance. Their reduction, which is necessary to prevent the enemy from infiltrating and reoccupying them, is a laborious and time consuming task. For these reasons an effort is normally made to bypass them and destroy them later by an attack from the rear. If this course is not practical, they are reduced by frontal attack. The task of assaulting and destroying fortified positions is one of the major support roles undertaken by engineer troops in combat.

55. Reconnaissance

Before the attack begins, an engineer study of terrain, bridges, routes of communications, artificial obstacles, and fortifications is made. The best source of information for this study is from an actual ground reconnaissance. For areas where ground reconnaissance is not practicable, aerial reconnaissance and photographs are used.

56. Engineer Support

The engineer support in an assault on a fortified position is basically the application of the same techniques used for breaching any obstacle of significant size. The assault of a fortified position is usually conducted by a combined arms team, and under heavy fire. During the attack, the principal mission of the engineers is breaching the outer and larger obstacles which protect the main fortified position. Specially organized and equipped infantry squads are charged with the reduction of weapons emplacements, bunkers and pillboxes, and the clearing of minor and close-in obstacles. Close coordination is essential between those engineers breaching the line of obstacles and those infantry squads reducing the fortifications. After the fortified line has been breached, the primary engineer task is the maintenance of routes to and through the gaps, with a secondary mission of destroying, by demolition, the captured forts or pillboxes.

57. Methods

When reducing field fortifications by the use of explosives, the techniques used are essentially the same as those employed in the reduction of concrete walls. Mechanical means are usually not effective for a large scale reduction of permanent fortifications. Combat engineer vehicles are used to great advantage in the destruction and removal of obstacles because of their armor protection, mobility under fire, and special accessories. Bulldozers are effective in surmounting or bridging of

obstacles and the rapid construction and maintenance of routes through the gaps. Other engineer equipment is used to clear rubble and debris resulting from the demolition of the fortifications. If all captured fortifications must be made unusable, earth can be bulldozed into the entrances as a temporary substitute for demolishing them.

58. Adjustment of Fire

Often the engineer soldier will require assistance from the artillery or the heavy weapons organic to the infantry in reducing obstacles or suppressing enemy fires in order to accomplish his mission in the assault of fortifications. Additionally, he may observe targets of opportunity that could be eliminated or put out of action if he could call for and adjust artillery fire. The techniques involved in the conduct of adjusting artillery fire are not difficult to master; they are fully covered in other manuals. It is suggested that additional reading and study on these techniques be made. The basic techniques are found in chapter 9, FM 23–90.

59. Organization

Engineer clearing parties are organized into task groups to accomplish the supporting mission of the engineers in an assault of a fortified position. These groups are used for the following specific tasks:

a. Preceding the breaching personnel to clear antipersonnel mines

b. Breaching or neutralizing a particular obstacle.

c. Marking the boundaries after a breakthrough.

d. Providing local security.

e. Standing by as a reserve to replace or reinforce, as the casualties are normally heavy in this type of operation.

CHAPTER 9

BRIDGES

Section I. INTRODUCTION

60. Importance of Bridging Tasks

Bridges play a significant role in war since they are a means by which natural obstacles can be crossed. To assist friendly forces in overcoming these obstacles, each engineer soldier can expect to participate in frequent bridging tasks.

61. Types of Bridges

Consistent with current military engineering concepts, bridges generally fall into one of three categories—

a. Floating bridges.
b. Fixed standard bridges.
c. Fixed nonstandard bridges.

Section II. FLOATING, FIXED STANDARD, AND FIXED NONSTANDARD BRIDGES

62. Floating Bridges

a. Floating bridges are used to support tactical crossing of water obstacles which cannot ade-

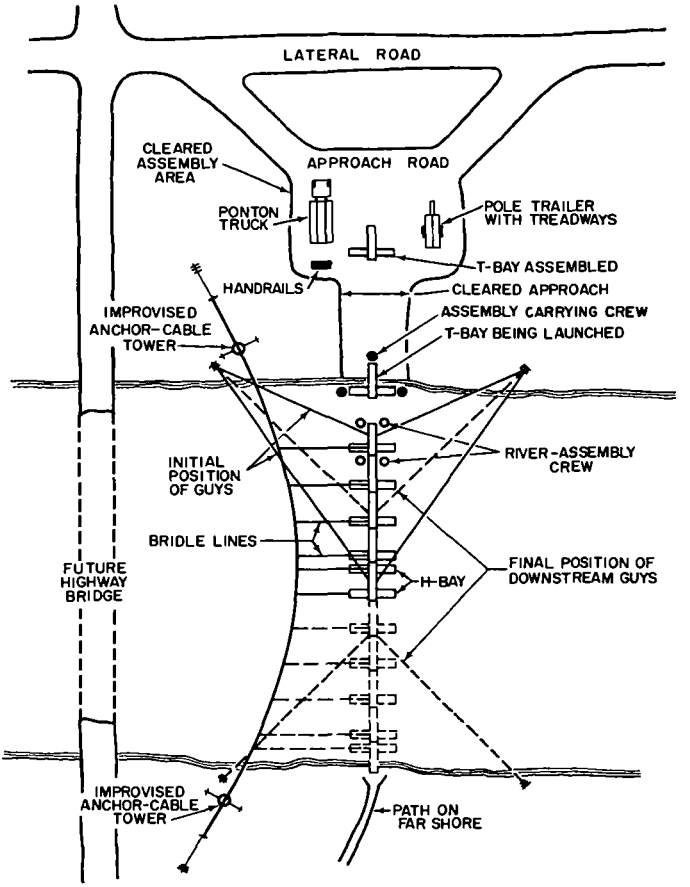


Figure 167. Schematic layout of near-shore assembly area for assembly by successive bays.

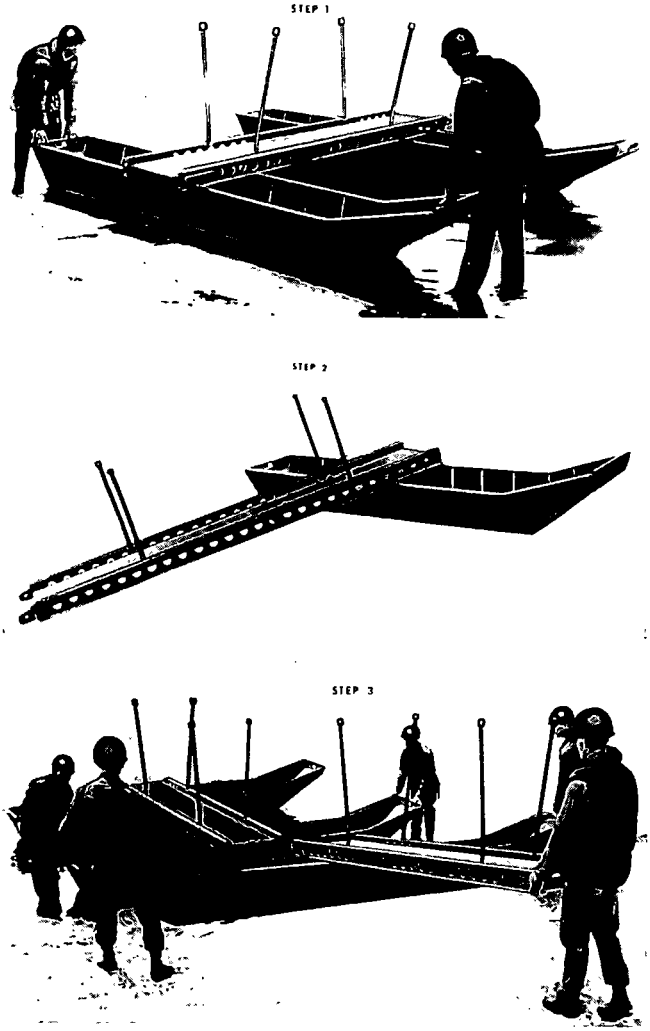


Figure 168. Assembly of footbridge by successive bays.

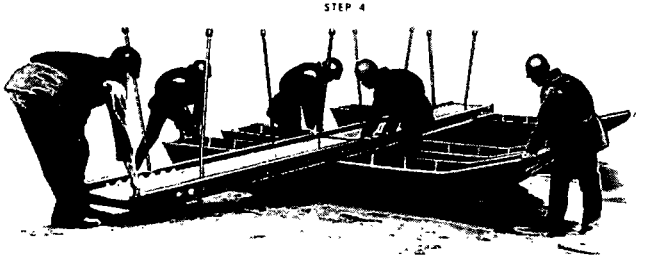


Figure 168—Continued.

quately be spanned by other bridging equipment within the time limits of an operation. There are two types of floating bridges—

(1) Vehicular.

(2) Foot.

b. Common Characteristics. All types of floating bridges currently in use have certain common characteristics as follows:

(1) All require an anchor system.

(2) All components are vehicle and air transportable and are designed for assembly by hand wherever possible.

(3) The basic pneumatic float assemblies on the heavy tactical bridges are interchangeable.

(4) Components can be assembled as rafts and used for ferrying operations.

(5) Specific bridge units are organized and equipped to provide— transportation and maintenance for floating bridges; and also technical assistance in the assembly and construction of bridging.

c. Specific examples of floating bridge construction and assembly are graphically presented in figures 167 through 178.

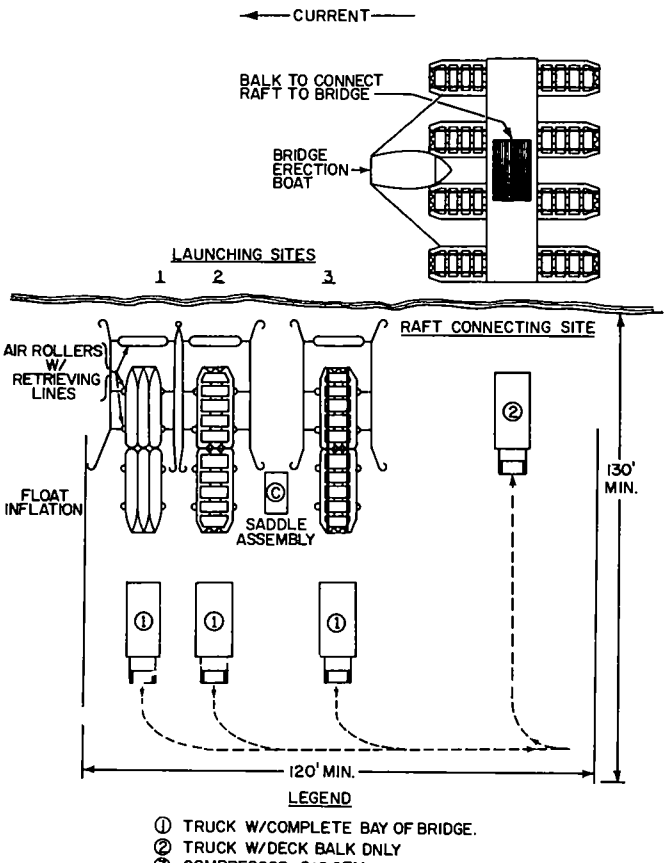


Figure 169. Typical layout of assembly area in M4T6 bridge construction.

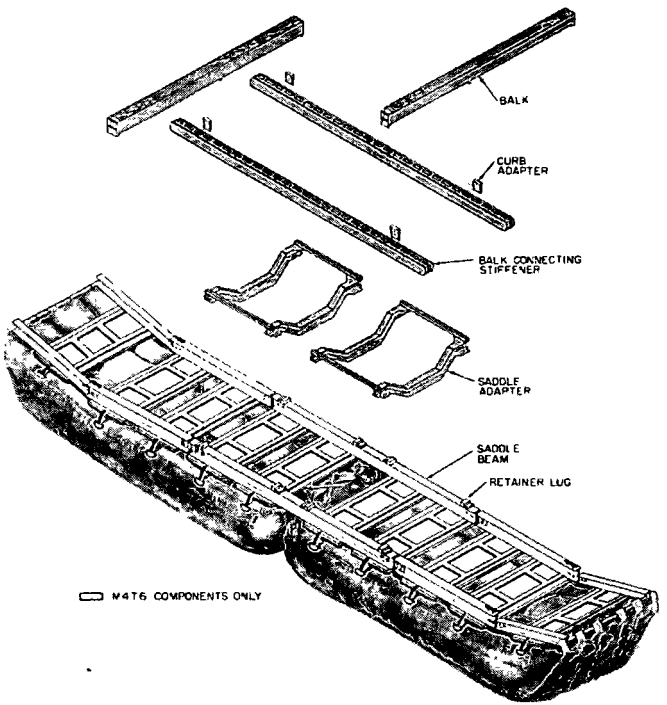


Figure 170. Details of a 24-ton float and saddle system.

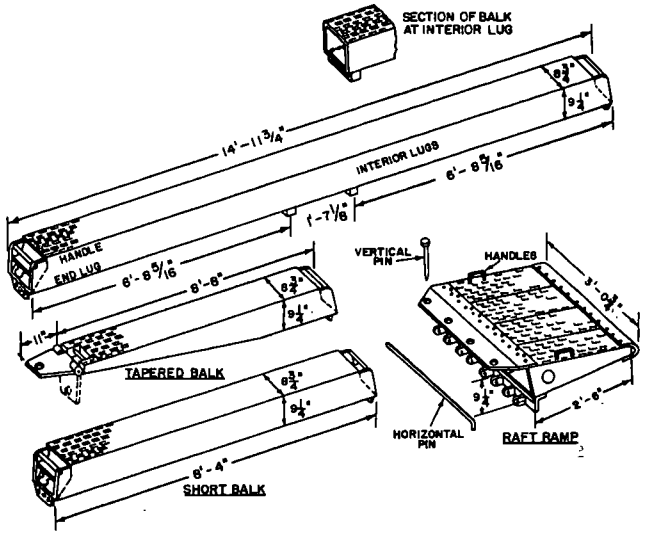


Figure 171. Types of deck balk.

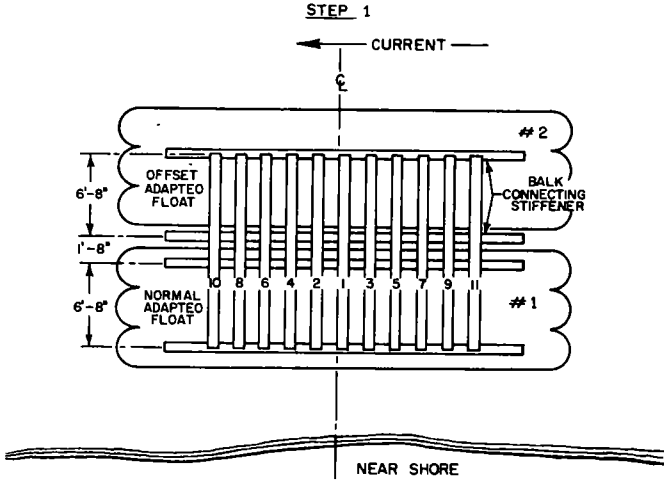


Figure 172. Assembly of reinforced end section (M4T6).

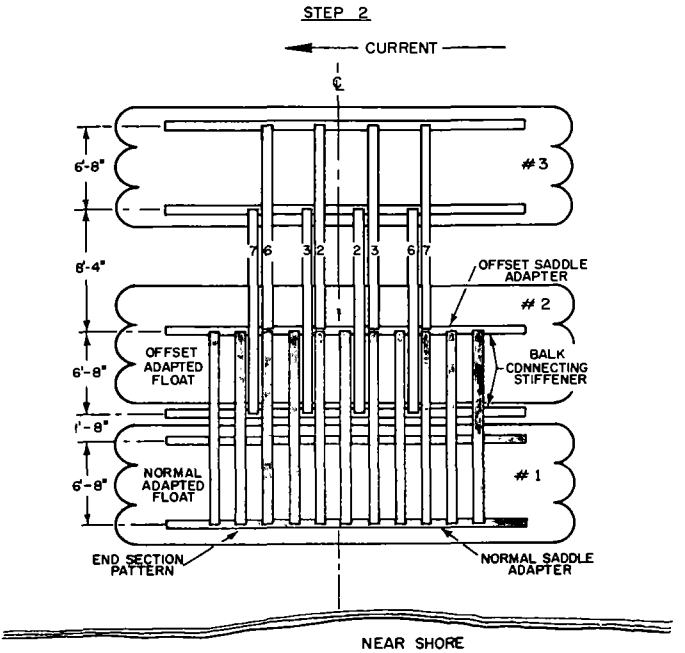
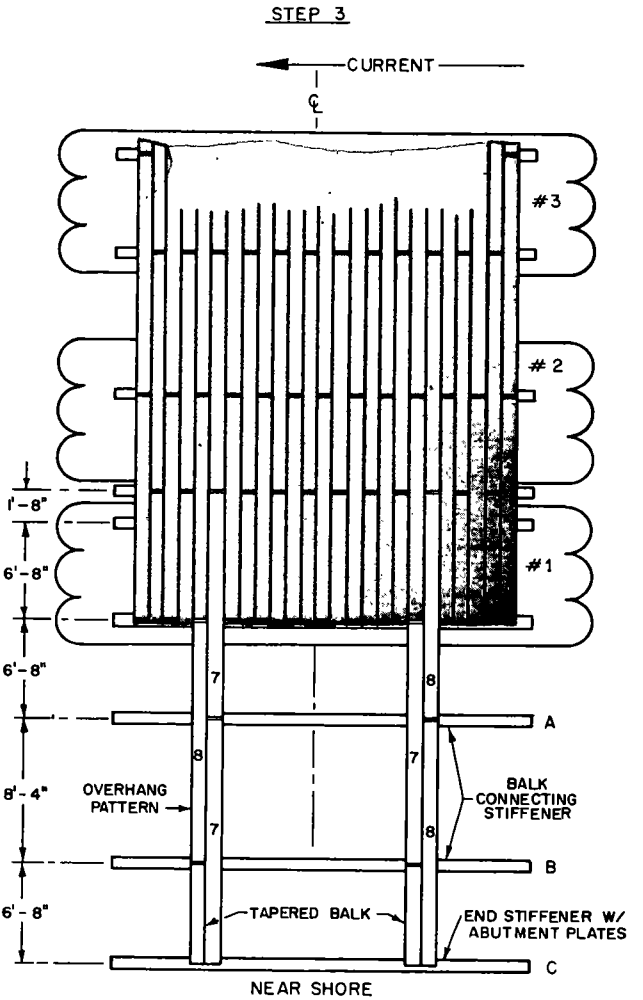


Figure 172—Continued.



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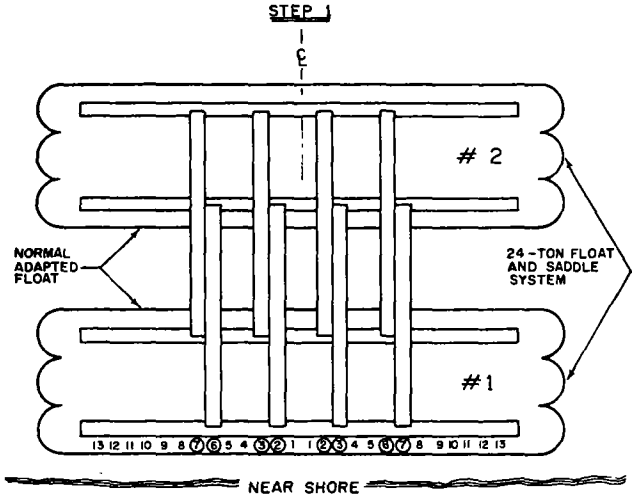


Figure 173. Assembly of 4-float raft.

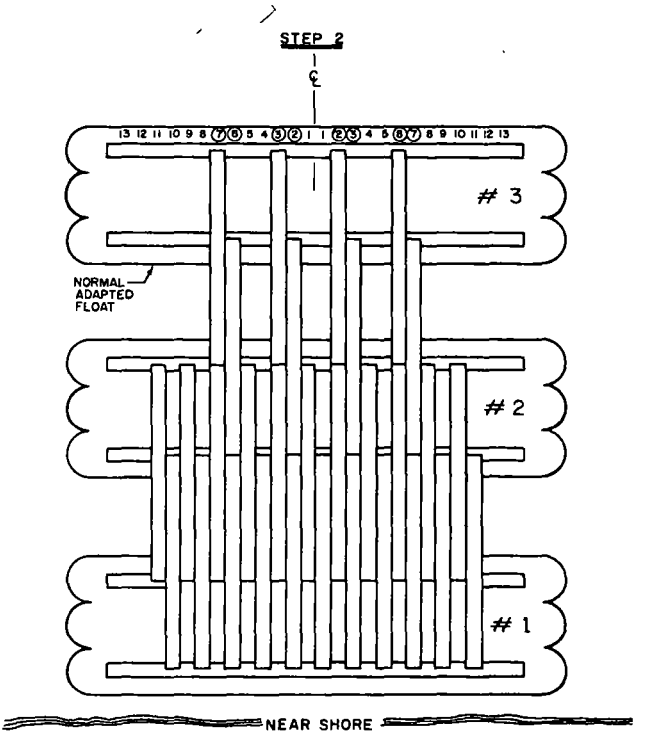
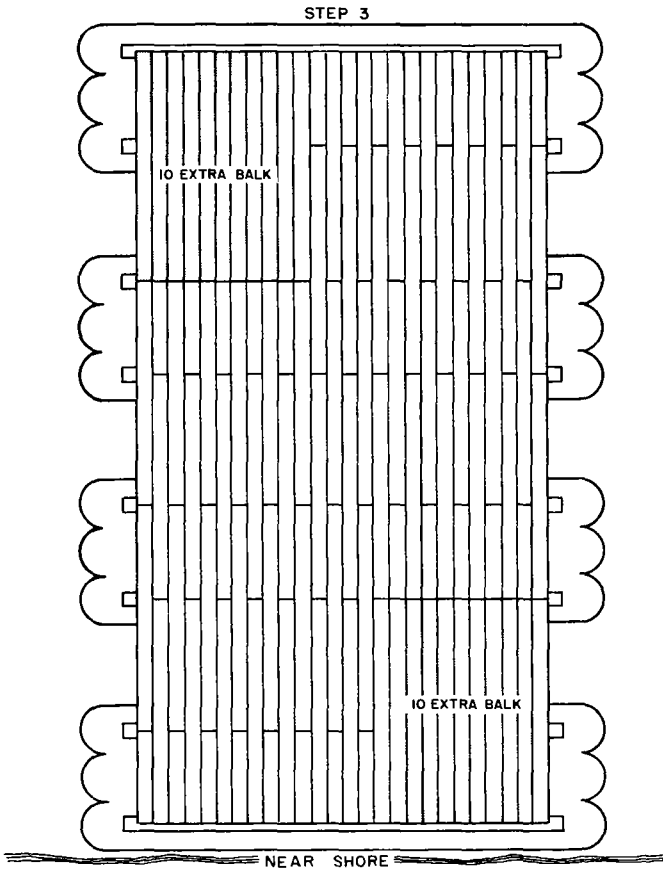


Figure 173—Continued.



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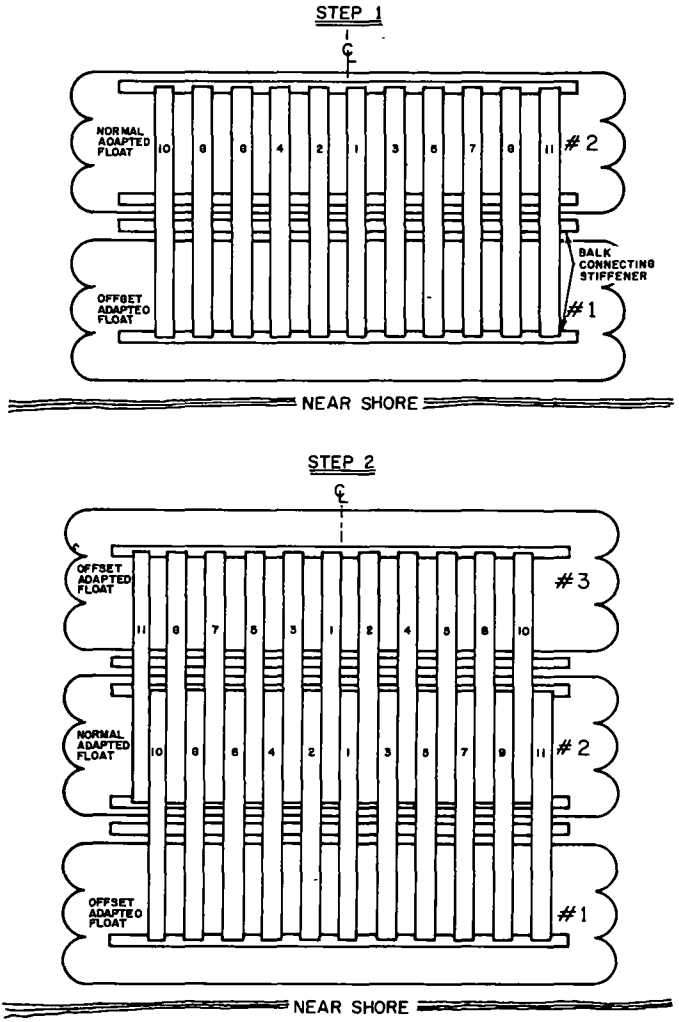


Figure 174. Assembly of 5-float reinforced raft.

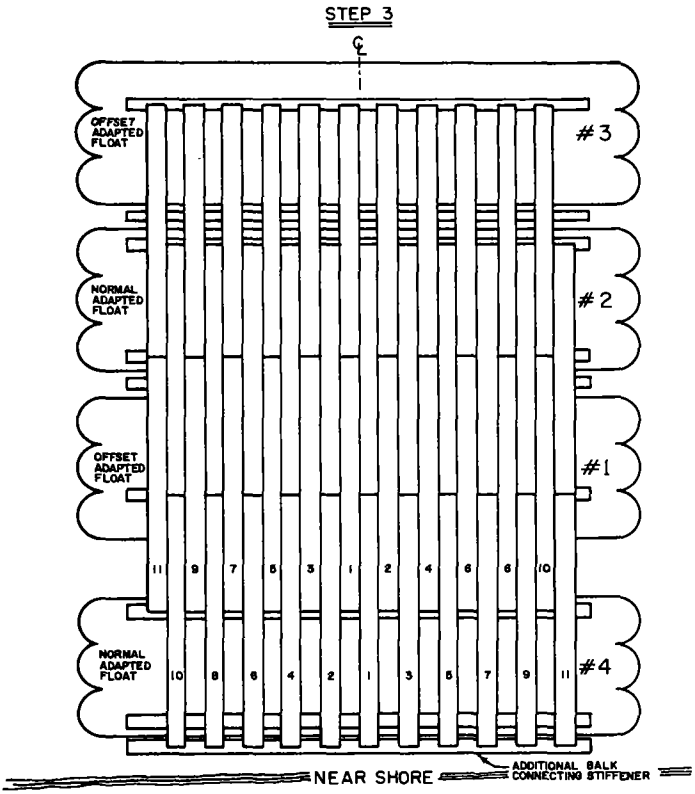


Figure 174—Continued.

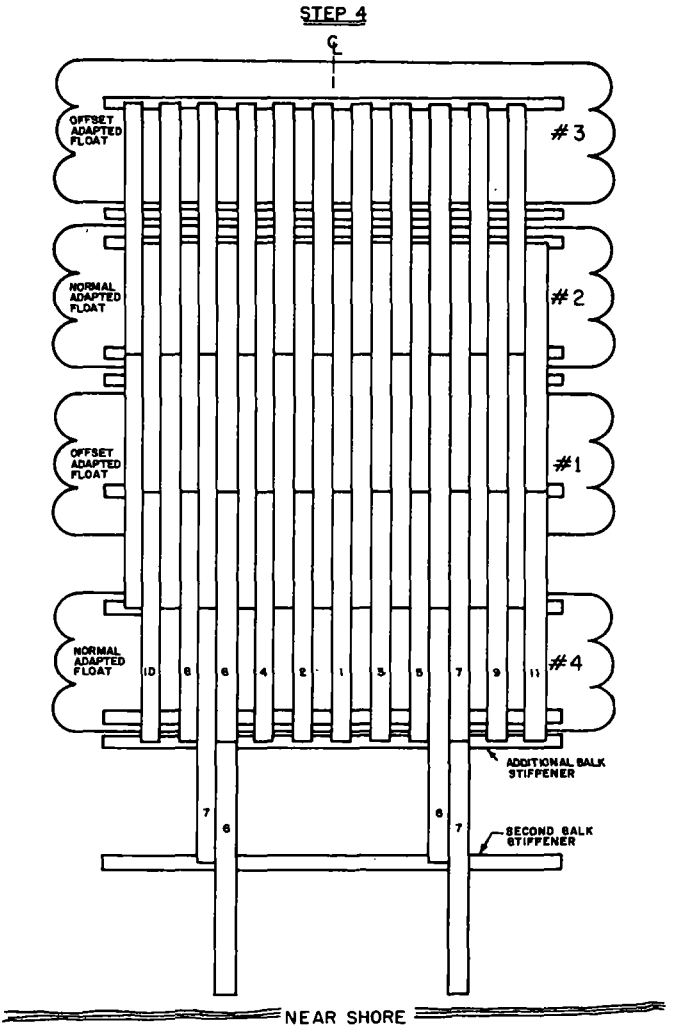
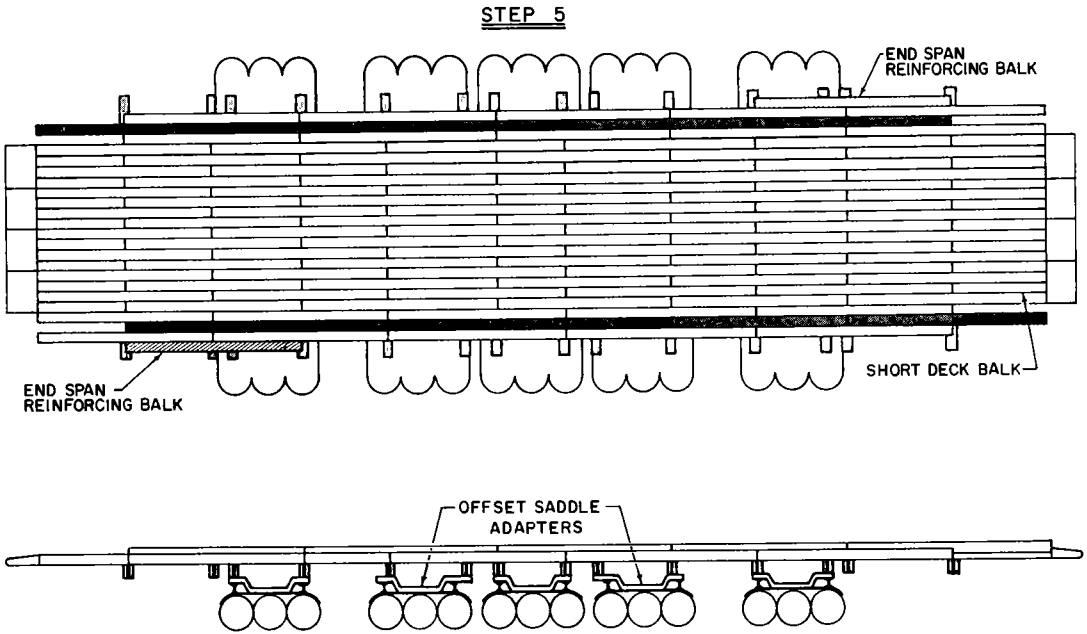


Figure 174—Continued.



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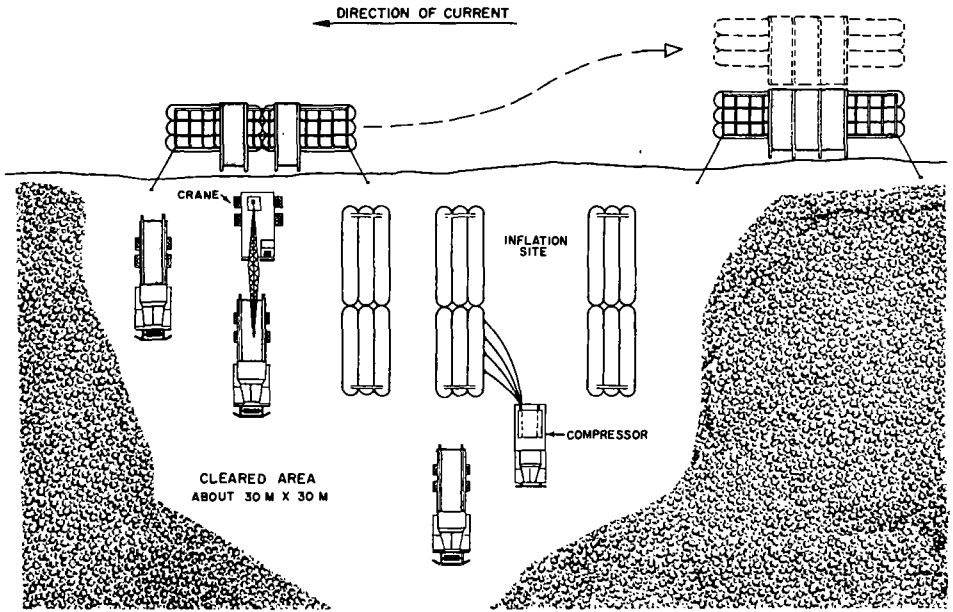
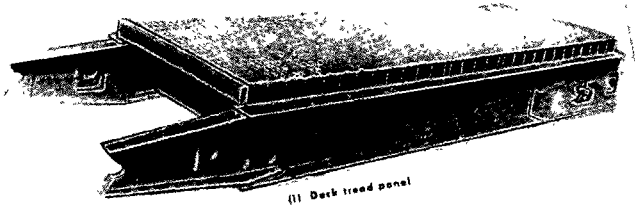


Figure 175. Typical layout of assembly area for class 60 bridge construction.



(1) Deck tread panel

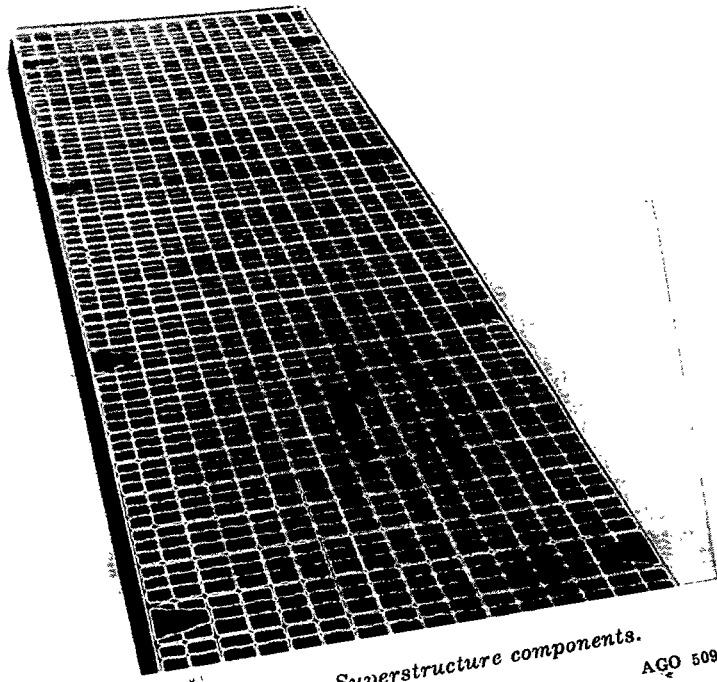


Figure 176. Superstructure components.

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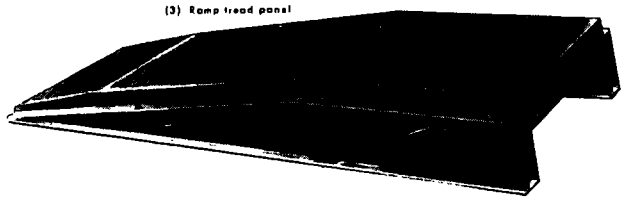
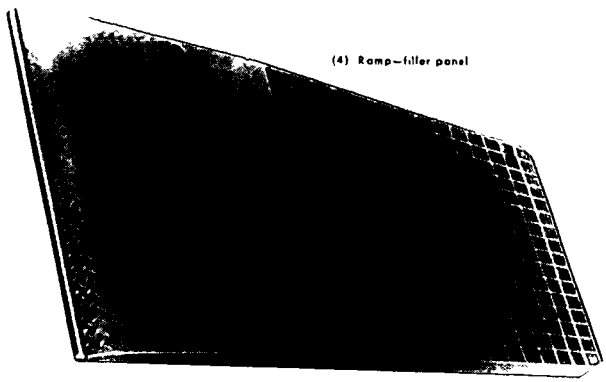




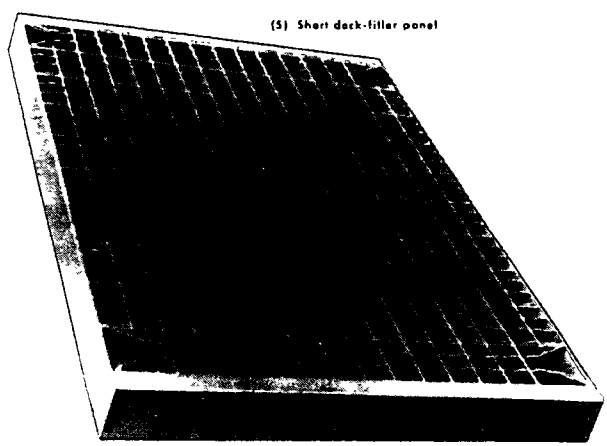
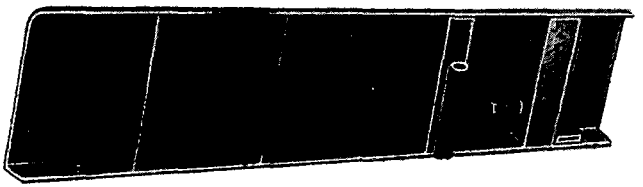
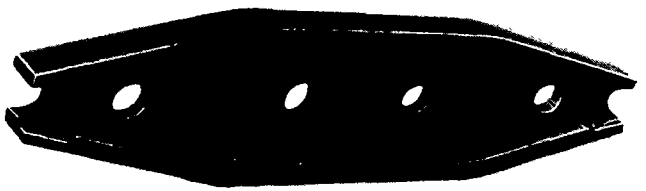


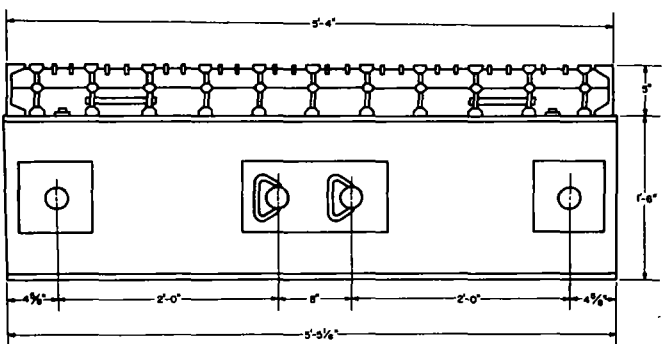
Figure 176—Continued.

(6) Short deck curb





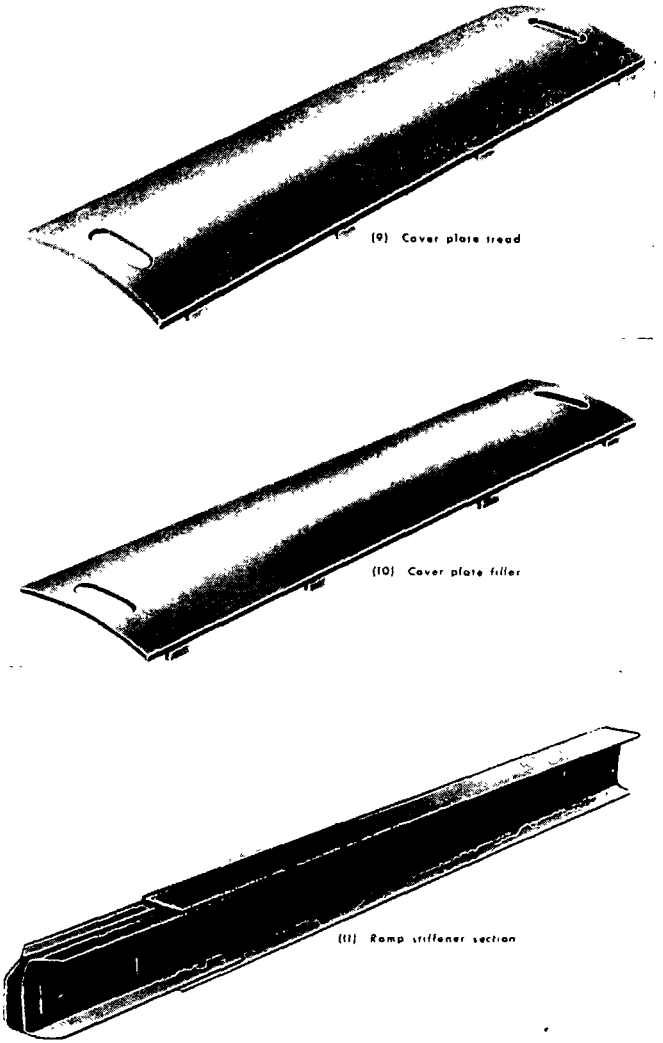
(7) Connector beam



(8) Short deck - tread panel.

SIDE ELEVATION

Figure 176—Continued.



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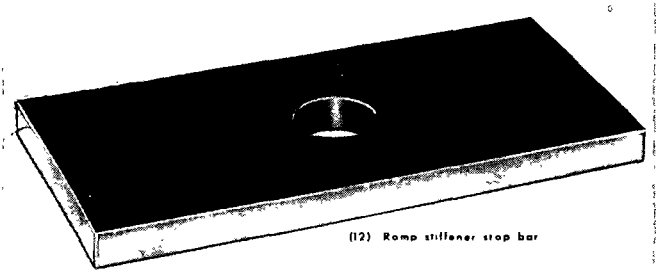
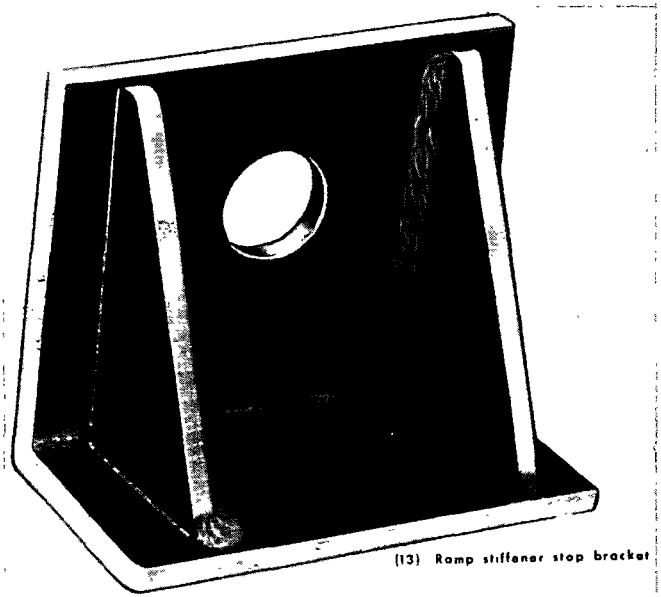


(12) Ramp stiffener stop bar



(13) Ramp stiffener stop bracket

Figure 176—Continued.

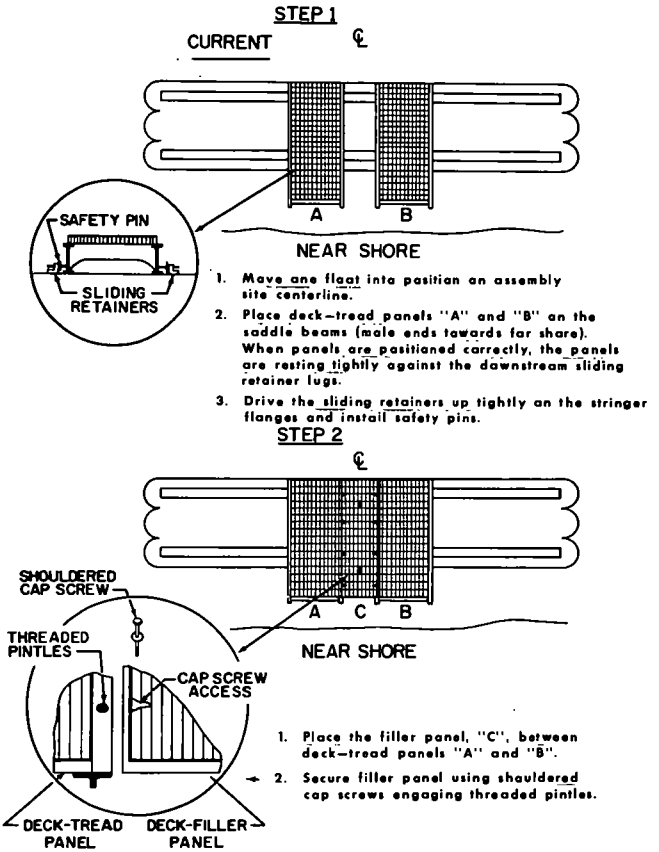
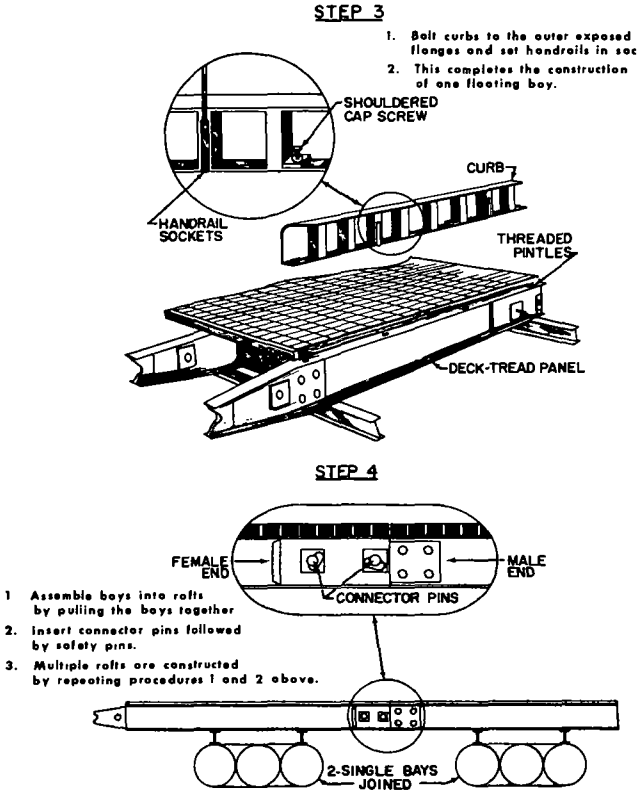


Figure 177. Superstructure assembly of class 60 bridge.



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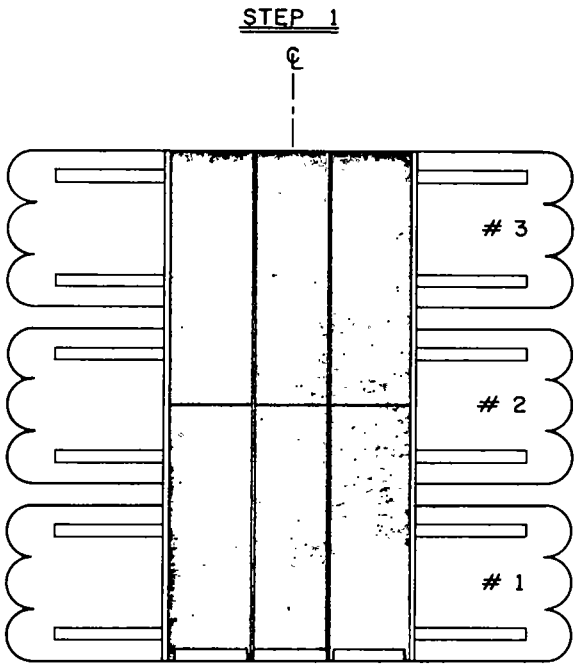
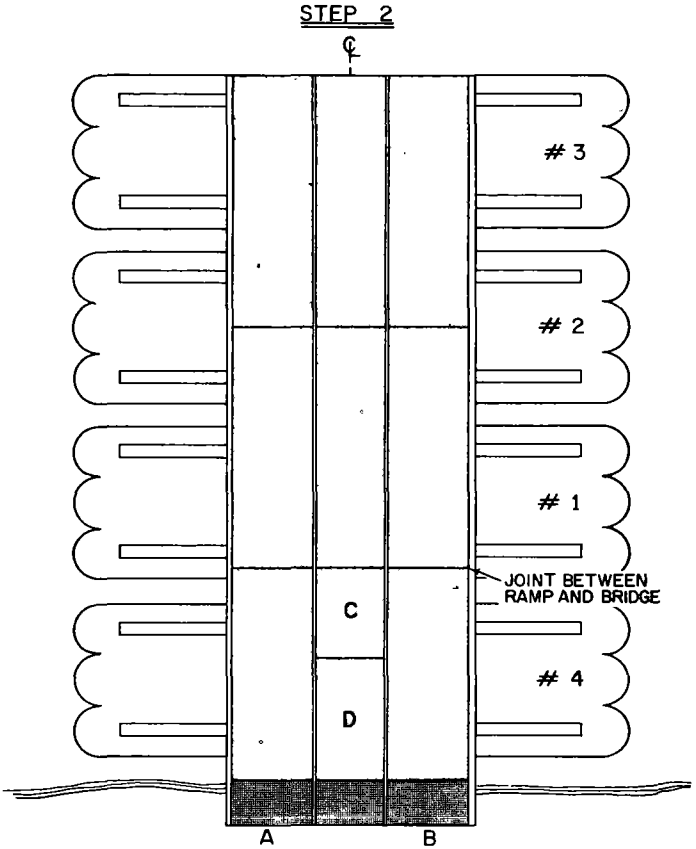


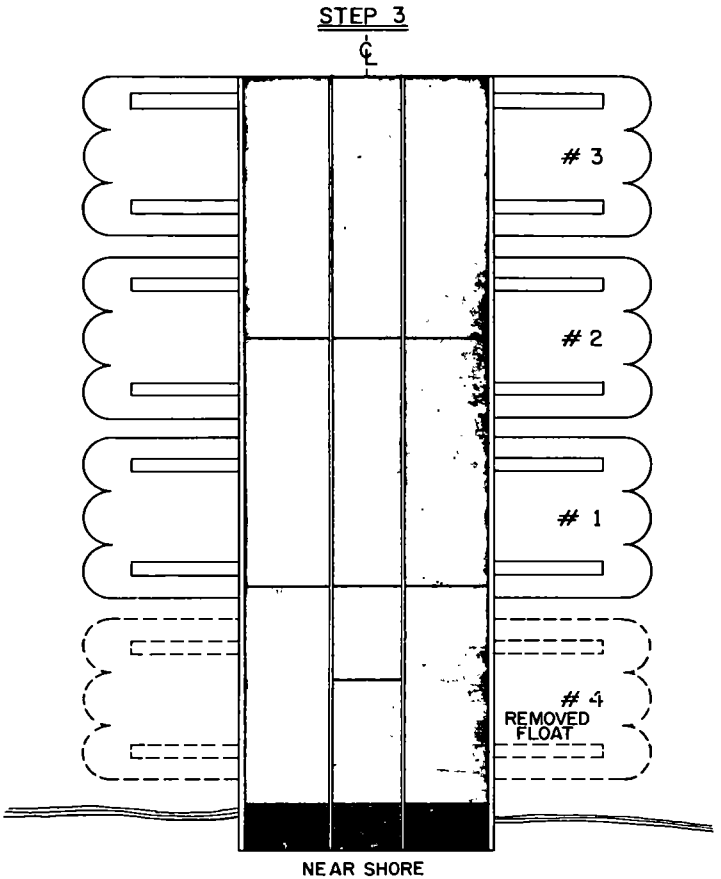
1. Move three floats into position on centerline.
2. Using a crane, place two bays of deck-tread and filler-panels across the saddle beams of all three floats.
3. Position panels and complete superstructure as decribed in steps 1 through 3, figure 177.

Figure 178. Assembly of end sections of class 60 bridge.



1. Move floot number 4 into position on centerline os shown.
2. Using a crane, place ramp-treod ponels "A" ond "B" ocross saddle beoms.
3. Ploce short deck-filler panel "C" ond ramp-filler panel "D"
4. Complete superistructure af ramp-bay section as described in step 3 figure 177.
5. Connect campleted romp-boy section to 3-float roft section.
6. Ploce caver plotes over the romp jaint.

Figure 178—Continued.



1. Move 4-floot complex to centerline of bridge erection site.
2. Remove floot number 4 from beneath romp-boy section by defloting or lifting romp-boy section with crane.

Figure 178(3). Assembly of end section of class 60 bridge - continued.

Figure 178—Continued.

63. Panel Bridge, Bailey Type, M2

a. Description. The most common type of standard fixed bridging found in the theater of operations is the M2 Bailey Bridge. The bridge resembles a large erector set. That is, it consists of numerous standardized parts which can be assembled comparatively easily into several different types of bridges. The bridge is designed so that it can be constructed by hand. Therefore, it is essential that the engineer soldier acquire a general knowledge of the bridge.

b. Components. There are several major components of the bridge which are important to know before bridge types can be discussed. Figures 179 through 191 graphically present the major components of the M2 Bailey Bridge.

c. Types of Truss Assembly. The Bailey Bridge parts may be assembled in various ways to obtain the bridge capacity desired to cross specified loads. For greater strength, a second or third story of trusses can be added. Standard types of truss assemblies are shown in figure 192.

Type	*Usual Nomenclature*	*Abbreviation*
Single-truss, single-story	Single-single	SS
Double-truss, single-story	Double-single	DS
Triple-truss, single-story	Triple-single	TS
Double-truss, double-story	Double-double	DD
Triple-truss, double-story	Triple-double	TD
Double-truss, triple-story	Double-triple	DT
Triple-truss, triple-story	Triple-triple	TT

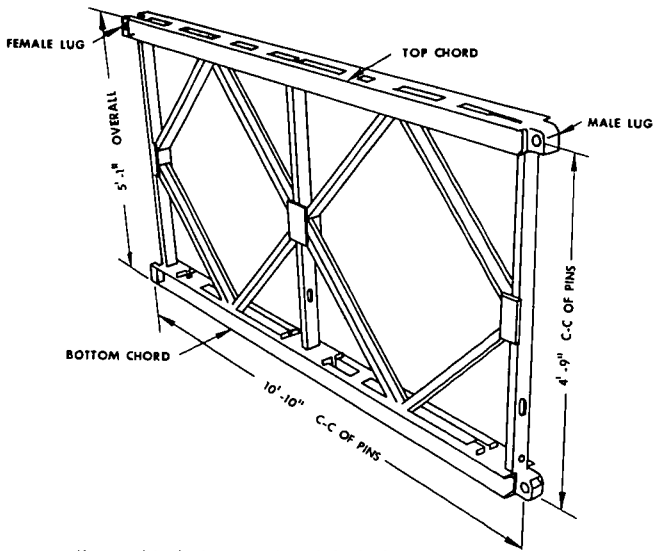
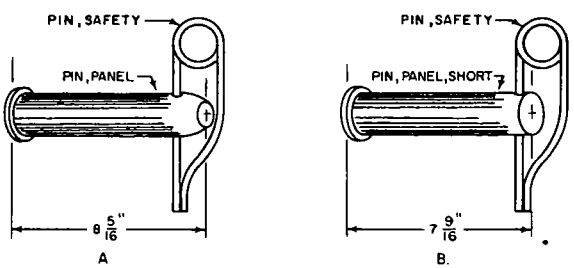


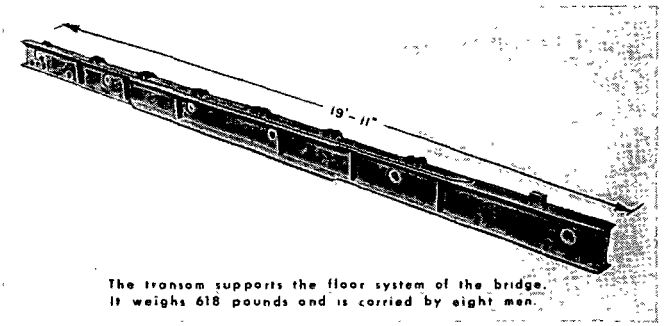
Figure 179. Panel.



Pin "A" is used to connect several panels together to form a truss. Pin "B" is used to pin the end posts of the outer truss in a triple-truss bridge.

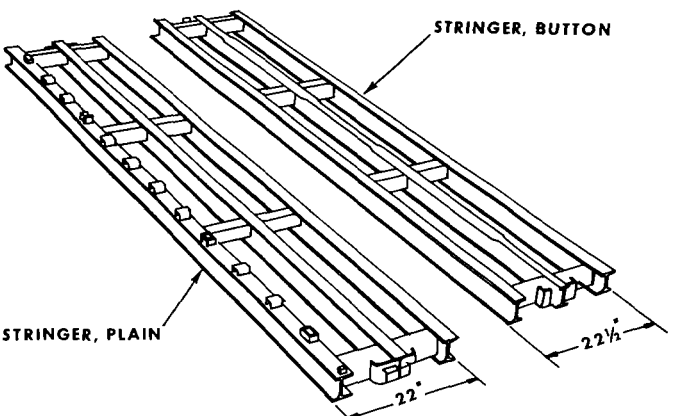
Figure 180. Panel pins.

d. Work Details for Single-Single (SS) Bridge. Generally, the easiest and quickest method of launching the SS bridge is by the *cantilever method.* This method consists of assembling the



The transom supports the floor system of the bridge. It weighs 618 pounds and is carried by eight men.

Figure 181. Transom.



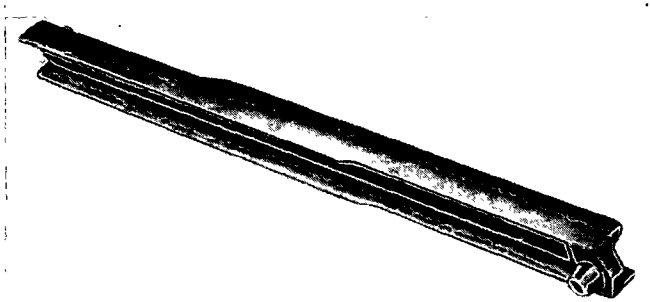
Stringers carry the roadway of the bridge. Each bay of the bridge has 4 plain stringers in the middle with a button stringer on each side.

Figure 182. Stringers.

The sway brace is hinged at the center end is adjusted by a turnbuckle. Two sway braces are required in the lower chord of each bay to increase stability.

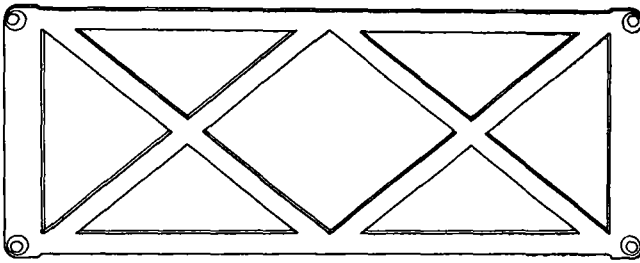
Figure 183. Sway brace.

bridge on rollers on one bank and pushing it across the gap, with enough weight kept behind the rollers on the near bank to balance the bridge and prevent it from tipping into the gap. Single-story bridges are usually assembled and launched by manpower. This manpower is broken down into several work details consisting of—*panel detail,* shown in figure 193, whose main function is carrying, placing, and pinning together panels in the launching nose and bridge; *transom detail,* whose main function is to carry, place, and clamp down transoms; *bracing detail* whose principal function is to obtain, install, and adjust sway braces, and rakers; and *decking detail* whose main



A raker connects the end of the transom to the top of the panels and prevents the panels from overturning.

Figure 184. Raker.

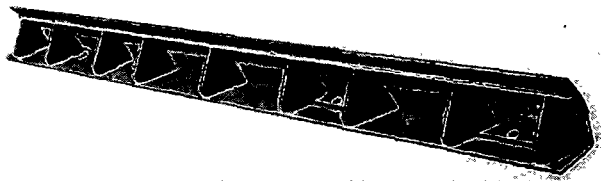


The bracing frame is bolted onto the top chords of two parallel panels in double truss type bridges and vertically on one end of each panel in two- and three-story assemblies

Figure 185. Bracing frame.

The tie plate is used only in triple truss bridges to secure the second truss to the third truss.

Figure 186. Tie plate.



The riband is fastened to the button stringer and forms a metal curb for the bridge.

Figure 187. Riband.

function is to lay stringers, chess, and ribands on bridge. Figure 194, shows a typical launching nose, while figure 195 graphically presents the components used in constructing one bay of SS bridge.

64. Fixed Bridges Assembled From Floating Equipment

a. The aluminum deck-balk used in the M4T6 floating bridge is often used to construct fixed bridges. The most popular bridge size constructed by this method is the 38-foot, 4-inch fixed bridge, commonly referred to as the *38-foot dry gap bridge.* The assembly of the 38-foot dry gap bridge is graphically illustrated in figure 196.

b. The superstructure of the class 60 floating bridge may be used to bridge gaps. A typical

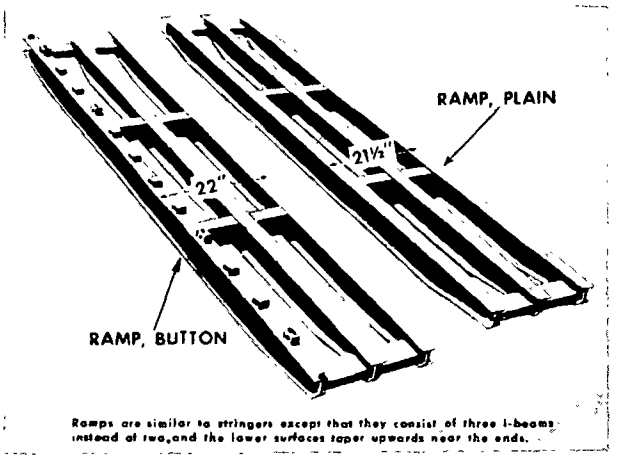
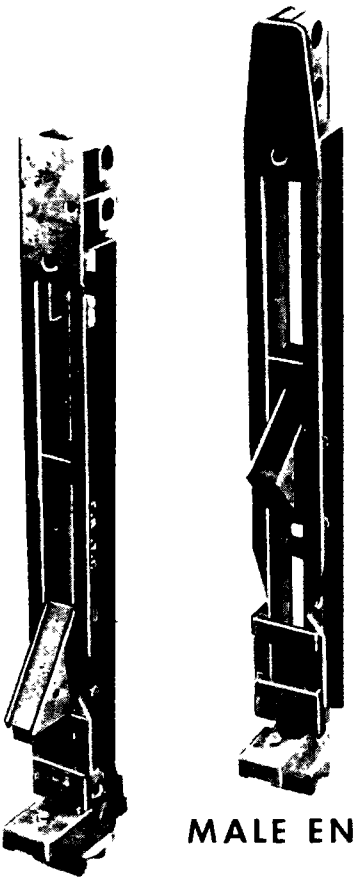


Figure 188. Ramps.

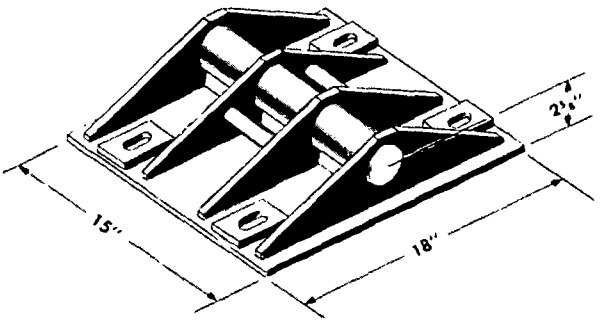


MALE END POST

FEMALE END POST

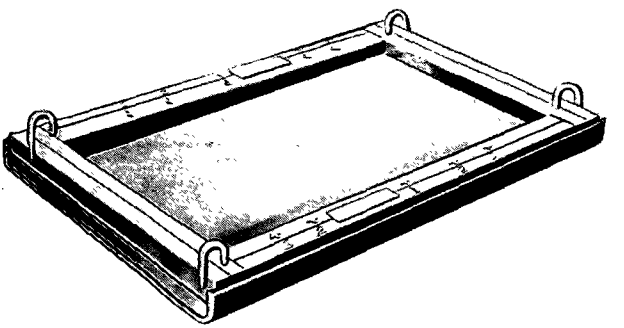
End posts are used on both ends of the bridge to take the vertical shear. There are two types — male and female.

Figure 189. End posts.



The bearing is connected to the bottom of the end posts and spreads the load of the bridge to the base plate.

Figure 190. Bearing.



The base plate is made of steel and is used to distribute the load evenly over the ground or grillage.

Figure 191. Base plate.

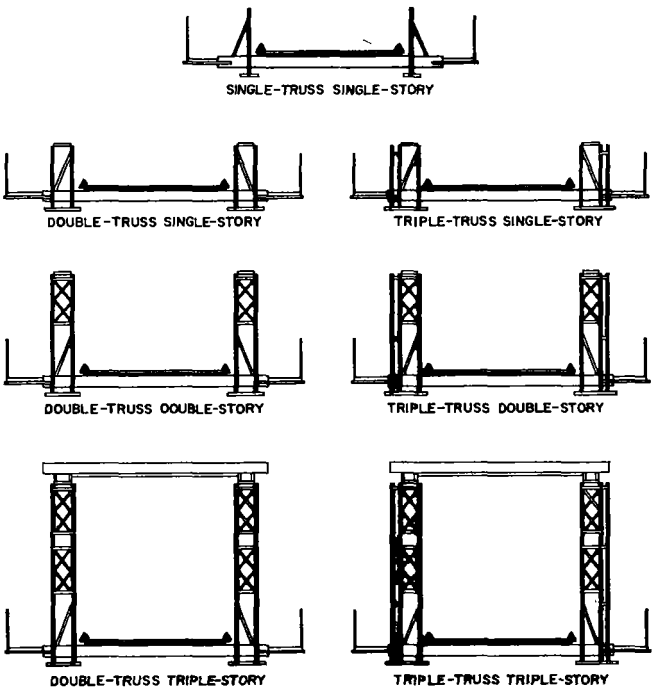


Figure 192. Standard types of truss assemblies.

superstructure being used as a fixed bridge is detailed in figure 197. Standard trestles are used in multiple-span bridges to support the treadways.

65. Armored Vehicle Launched Bridge (AVLB)

The AVLB (fig. 198) is a folding bridge designed to be transported, launched, and retrieved by a modified turretless tank. It will support the

heaviest division load and will span gaps up to 60 feet.

66. Wood Stringer Bridges

a. Timber Trestle. The nonstandard type bridge most commonly used is the simple span

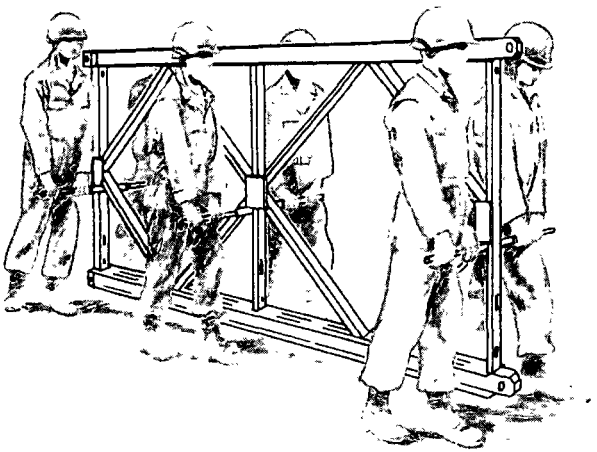


Figure 193. Panel detail.

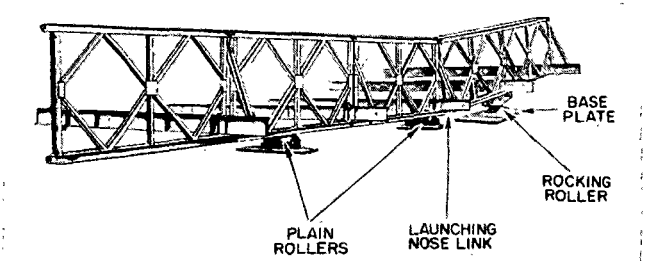


Figure 194. Typical launching nose.

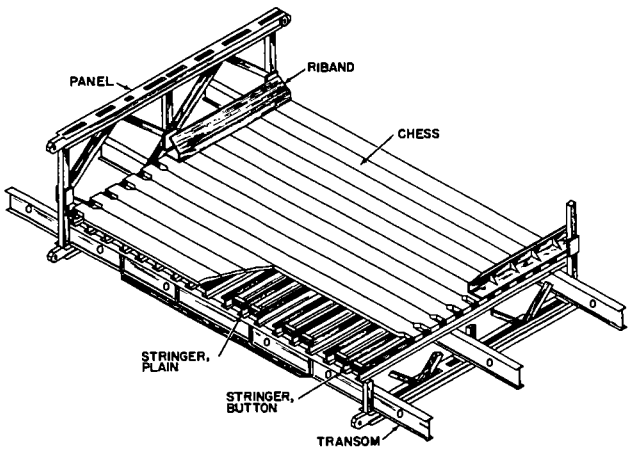
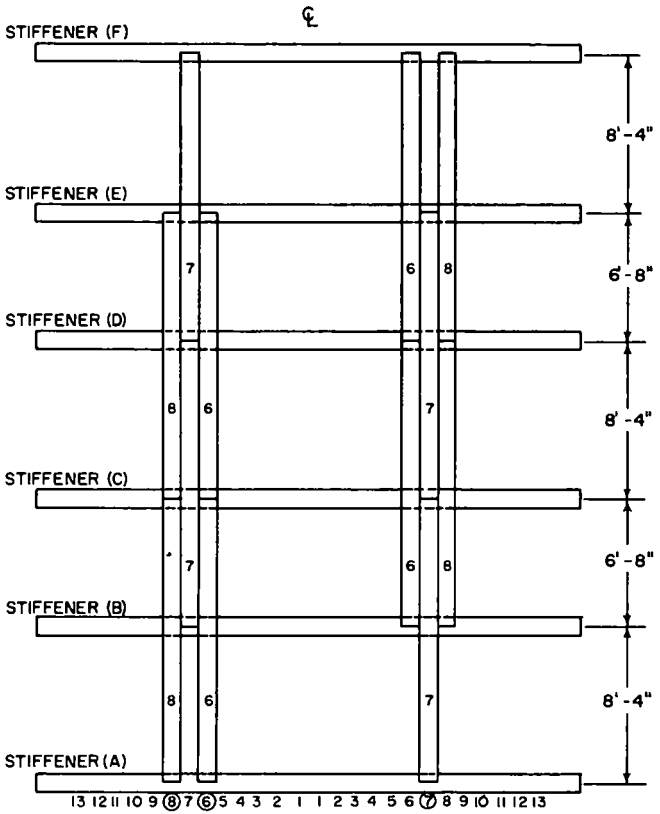


Figure 195. Components in one bay of a SS bridge.

timber trestle bridge on timber footings. In many cases, logs or railroad rails may be used as expedients in this type of construction. The bridge is usually of simple design and consists of *substructure* and *superstructure* components. Figure 199 illustrates typical substructure and superstructure components found in the timber trestle bridge.

b. Pile Bent. The pile bent is used with the nonstandard type bridge where the bottom is soft or marshy, or the water is deep and the currents swift. Pile bent construction calls for pile-driving equipment and skilled operators. Typical piers and bents are shown in figure 200.

STEP 1



1. Place six balk-connecting stiffeners on ground as detailed on centerline.
2. Connect balk as shown to balk-connecting stiffeners.
3. Insert all pins in lugs.

Figure 196. Skeleton frame assembly for 38-foot dry gap bridge.

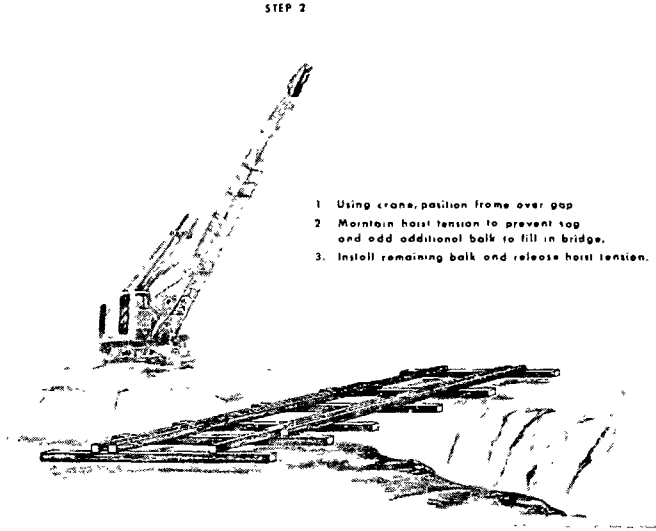


Figure 196—Continued.

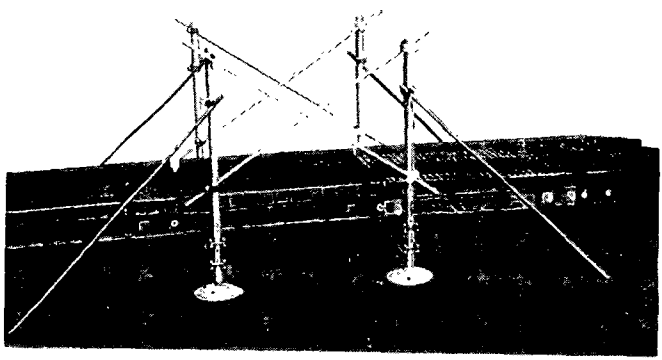


Figure 197. Fixed bridge constructed from class 60 components.

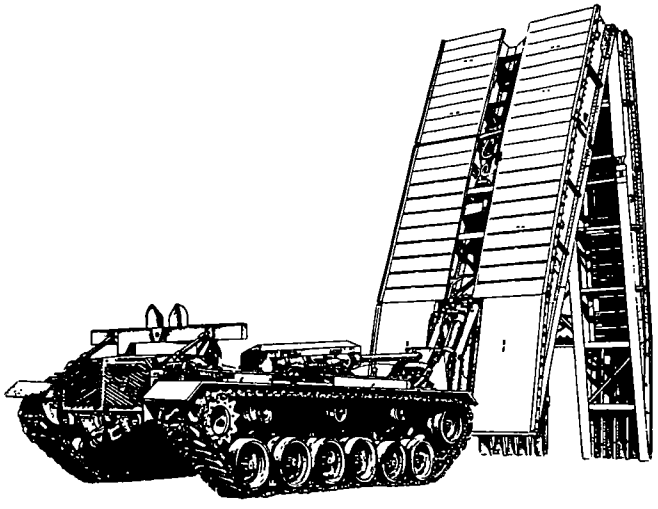


Figure 198. Armored vehicle launched bridge.

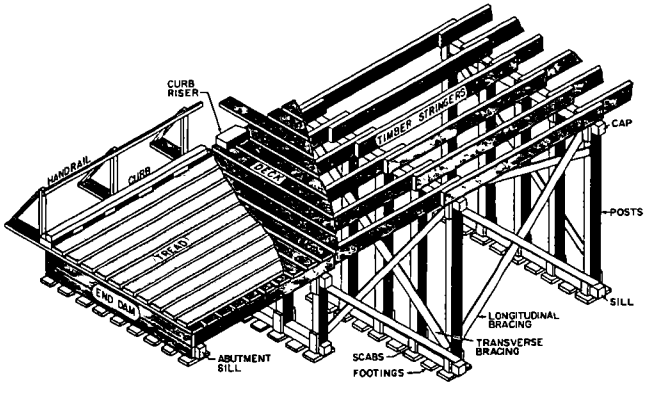


Figure 199. Timber trestle bridge.

Figure 200.—Pile bent and pile bent pier.

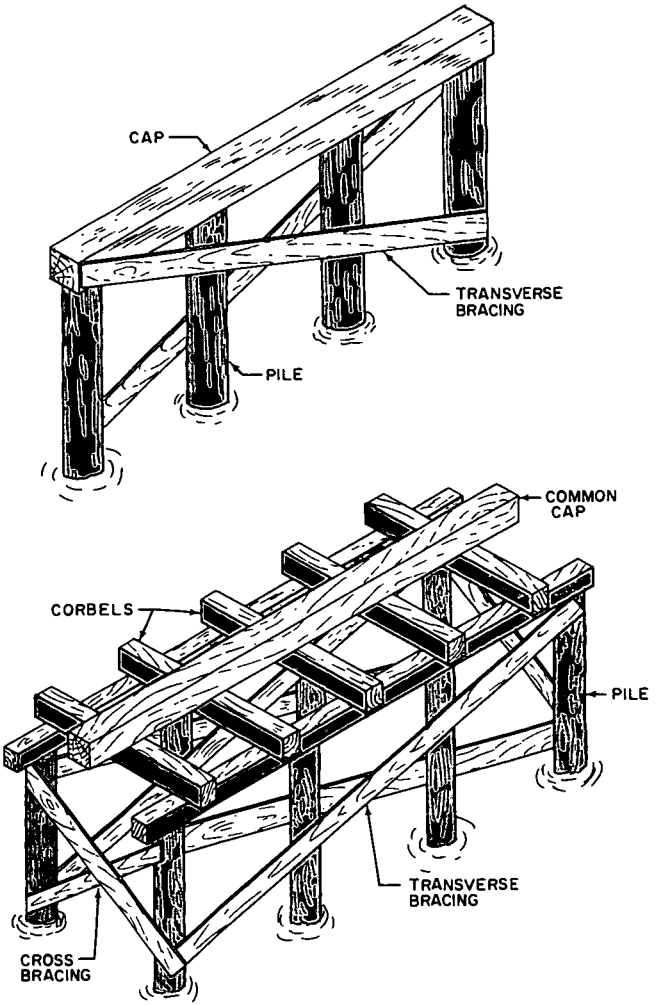


Figure 200—Continued.

67. Footbridge

Aluminum footbridge equipment is used to assemble paddle propelled ferries for light cargo, light vehicles, and wounded personnel. Figures 201 through 203 depict typical rafts assembled from footbridge equipment.

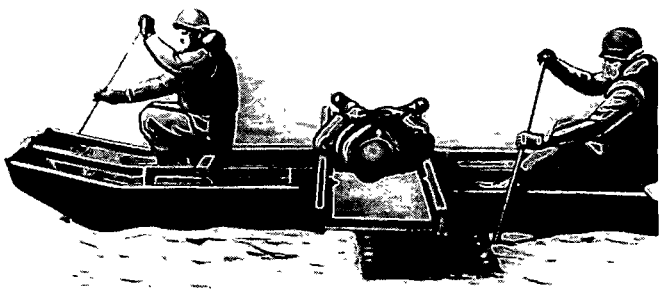


Figure 201. Two-ponton raft.

Figure 202. Three-ponton raft.

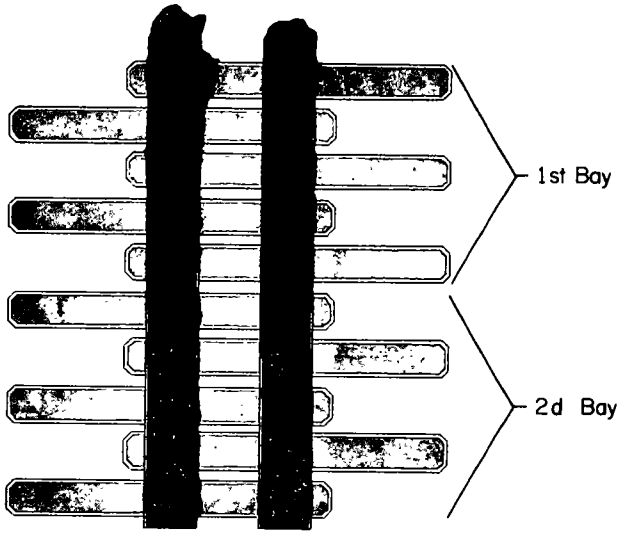


Figure 203. Light vehicle raft.

68. M4T6 Raft

The assembly of M4T6 bridge components for use as rafts is discussed in paragraph 62. The number of power boats used to propel these rafts is determined by the current velocity and types of raft which is constructed.

69. Ferries

a. Trail Ferry. A trail ferry (fig. 204) consists of a raft connected by hauling and maneuvering lines to a bicycle traveler which runs on a ferry cable stretched across the stream and secured to holdfasts on both shores. The force of the current acting against the canted pontons of the ferry

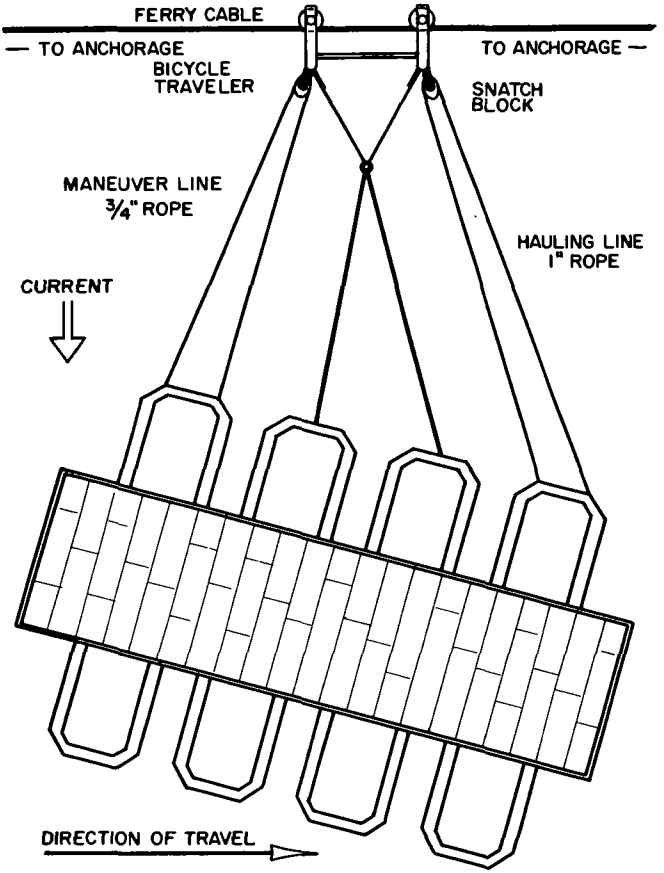


Figure 204. Trail ferry.

propels it from shore to shore. Trail ferries generally are used only when available motive power is insufficient or if tactical requirements, such as silent operation or complete blackout, dictate.

b. Flying Ferry. A flying ferry (fig. 205) works on the same principle as the trail ferry except the raft is held in the stream by an anchor well upstream from the crossing site. As the ferry moves shore to shore it describes an arc, the center of which is the anchor. The anchor cable should be at least 1½ times as long as the width of the stream and floats should be provided to keep the cable clear of the water.

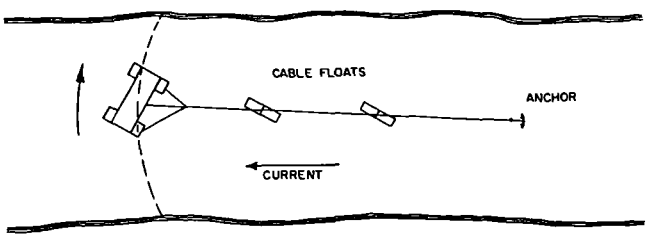


Figure 205. Flying ferry.

c. Free Ferry A free ferry is a current operated ferry which is not held in place by an anchoring system. Using poles and a rudder, the operator maintains the floats in a canted position to the flow of current, allowing the ferry to drift to the far shore. The width, depth, and current of the stream or body of water, and the character of the traffic to be moved, must be considered. Only personnel with considerable experience and skill in operating free ferries should be used where

waters are deep and fast moving and channel currents are unknown or treacherous.

Figure 206. Three-rope suspended walkway.

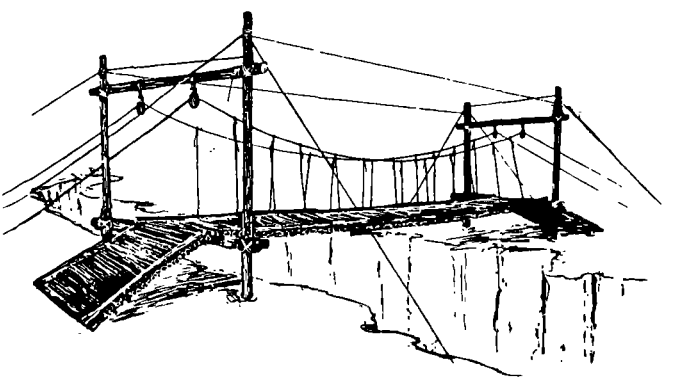


Figure 207. Suspended walkway of local material.

70. Suspension Bridges

Military suspension bridges are used to carry light loads over long spans where swift or deep streams, deep ravines, and difficult approach roads or trails make the use of standard bridging equipment impracticable. Types of expedient suspension bridges are numerous and are only limted to the ingenuity of the person designing and fabricating the bridge. Typical examples of expedient suspension bridges are detailed in figures 206 through 213.

71. Cableways

In general, the components of a cableway system include a track cable supported at the ends by towers, a trolley and carriage pulled along the track cable by a haul rope, and a power unit to operate the haul rope. Figures 214 through 217

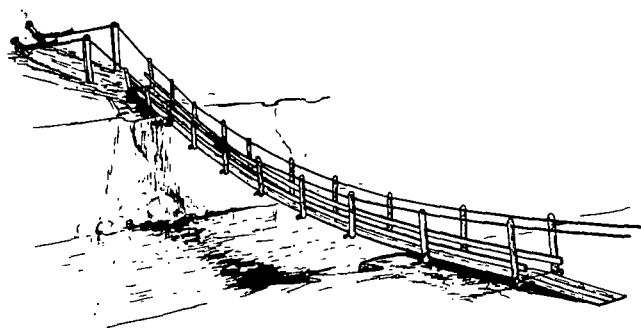


Figure 208. Expedient type suspended footbridge.

Figure 209. Suspension footbridge constructed of dimensioned lumber.

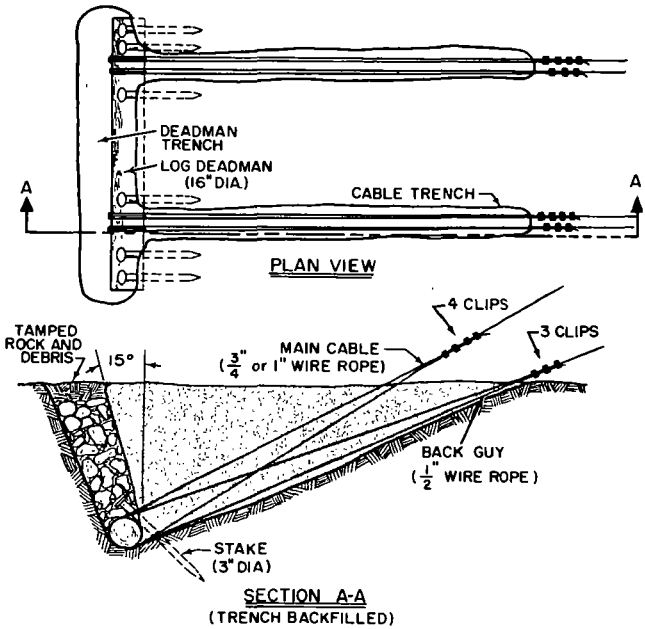


Figure 210. Typical deadman arrangement for suspension bridge.

present typical expedient cableway systems and construction techniques.

72. Expedient Rafts

In today's Army with all the technical advancements and sophisticated methods employed in river crossing operations, it is easy to lose sight of the fact that these means may not be available to the soldier at a particular time or place. When this occurs, expedient means must be devised to enable men and equipment to cross water barriers.

The types of expedient flotation equipment that can be devised are limited only by the individual soldier's ingenuity. Even the soldier's trousers (fig. 218) can be used to keep him afloat while crossing short streches of water. The more common stream crossing expedients are graphically portrayed in figures 219 through 223.

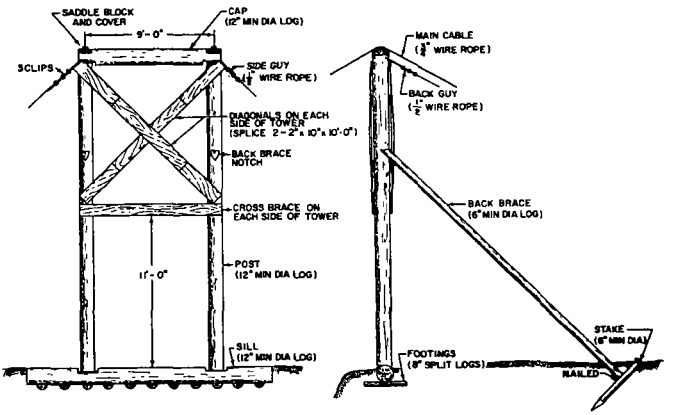


Figure 211. Improvised tower for suspension footbridges

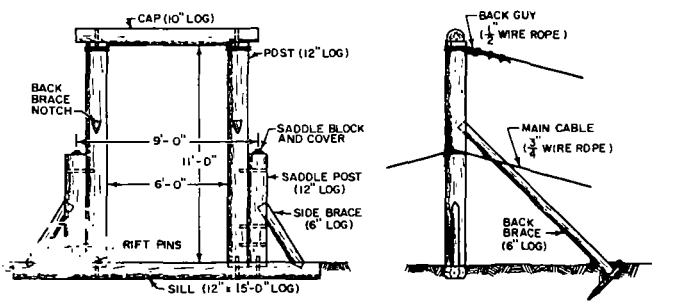


Figure 212. Modified tower for short (140 foot or less) suspension footbridges.

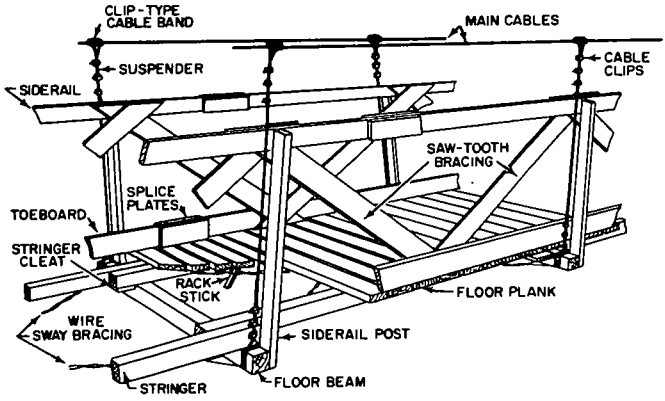


Figure 213. Detail of floor and siderail system for suspension footbridges.

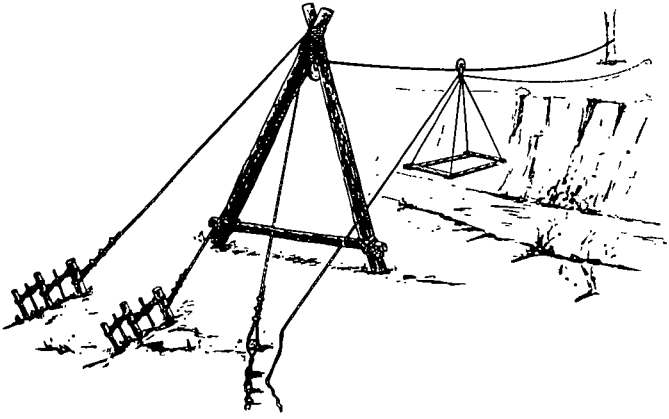


Figure 214. Simple field expedient cableway.

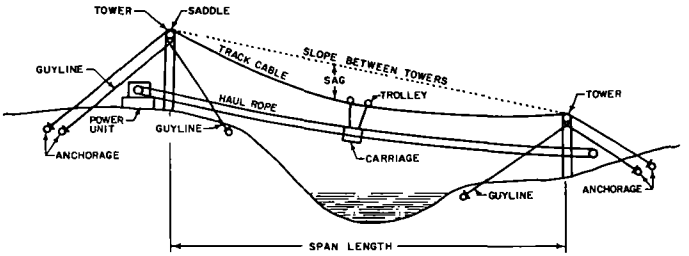
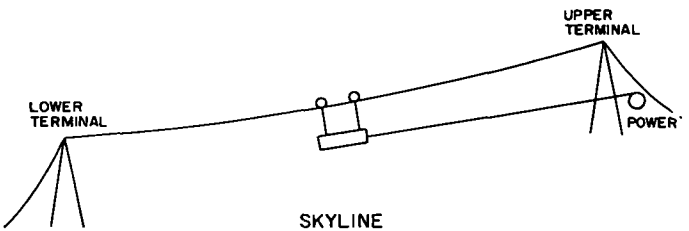
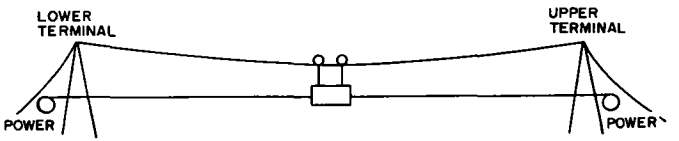


Figure 215. Nomenclature of components of a cableway system.





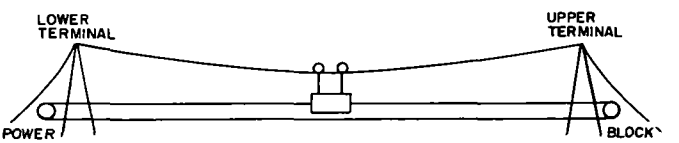


Figure 216. Diagram of haul rope arrangements

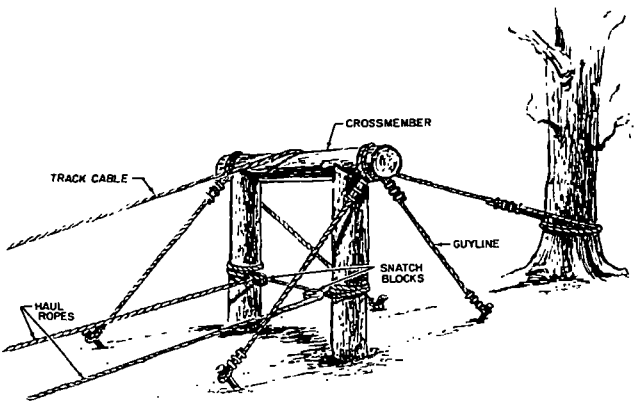


Figure 217. Expedient tower used with cableways.

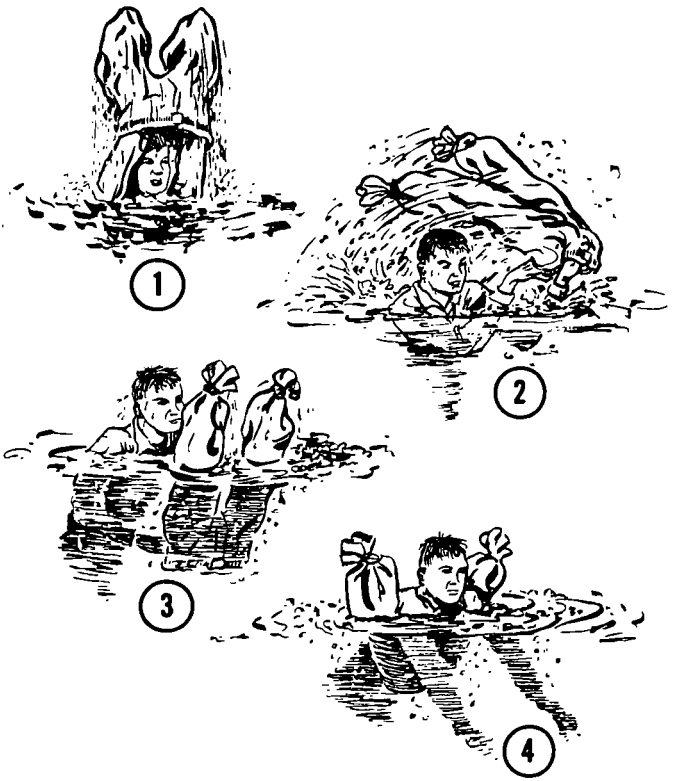


Figure 218. Trousers used as an expedient stream crossing method.

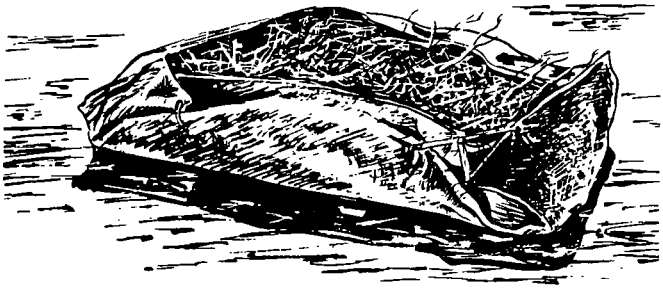


Figure 219. Tarpaulin or canvas filled with brush used as a raft.

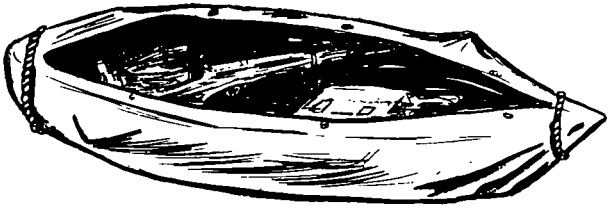


Figure 220. Expedient raft made from shelter half and field equipment.

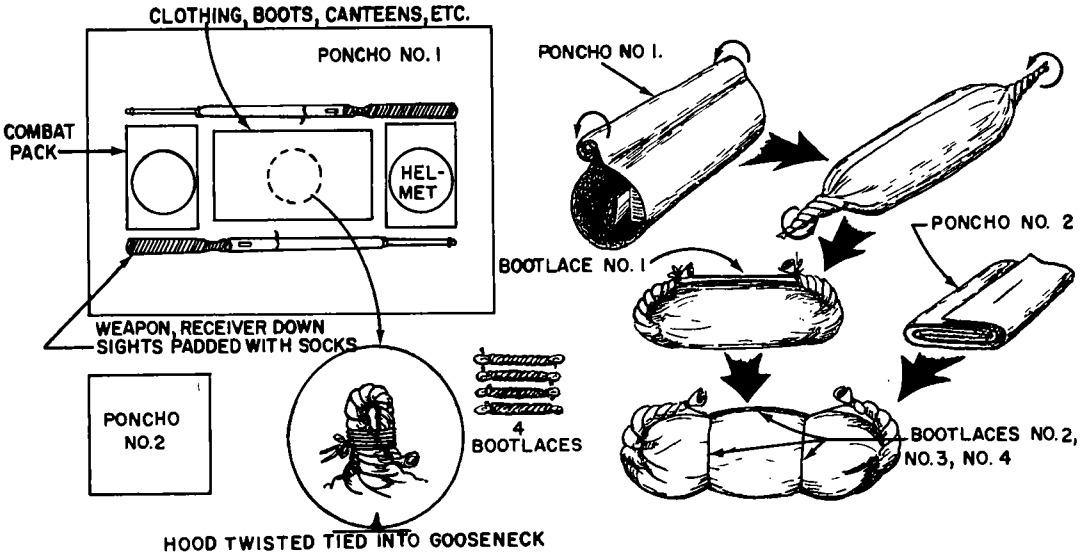


Figure 221. Australian raft.

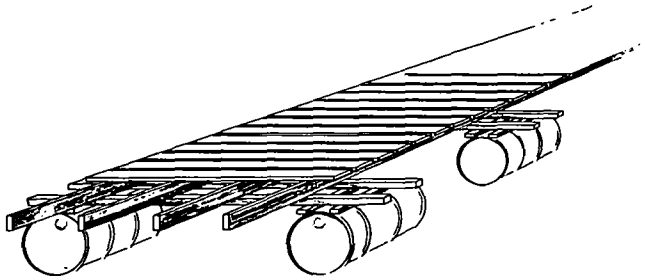


Figure 222. Raft made from oil drums and lumber.

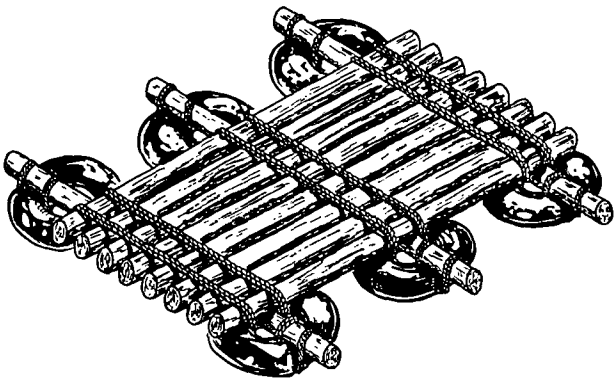


Figure 223. Raft constructed from inner tubes and logs.

CHAPTER 10

BOATS

73. Assault Boats, Plastic, 16-Foot

a. Design. The plastic assault boat (fig. 224) is a light craft designed to carry the leading elements in an assault stream crossing. It is equipped with 10 carrying handles to hand carry the boat to the stream.

b. Propulsion. Propulsion is by paddling or 25 horsepower outboard motor. Three engineer soldiers are assigned to each boat when propelled by paddling. The engineer soldier in charge is seated in the stern of the boat; his duties are to steer the boat and set the cadence for the paddlers. The other two engineer soldiers act as paddlers and are located in the bow, one on each side. Four infantry soldiers kneel on one knee along each side of the boat and assist in paddling.

c. Transportation. A stack of 10 inverted plastic assault boats can be carried on a 2½-ton utility pole-type trailer or on a 2½-ton 6 x 6 cargo truck.

74. Assault Boat, M2

a. Design. The M2 assault boat (fig. 225) is a lightweight craft constructed of plywood and designed to carry the leading elements of the assault

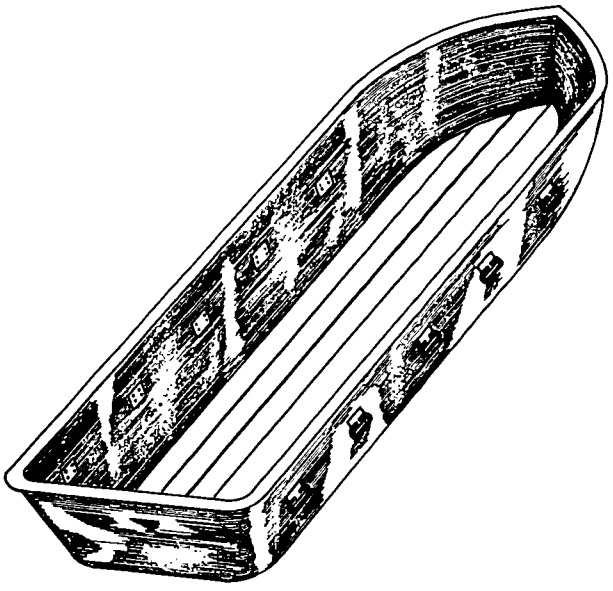


Figure 224. Sixteen-foot plastic assault boat.

in an assault stream crossing. Silent crossings are difficult as considerable noise results from paddles striking the plywood hull. Noise may be reduced by wrapping paddle handles in burlap to cushion them against the hull.

b. Other Details. Capacity, propulsion, and transporting of the M2 assault boat are the same as that prescribed for the plastic boat.

75. Fifteen-Man Pneumatic Assault Boat

The 15-man pneumatic assault boat (fig. 226) is a portable inflatable, boat made from a neoprene

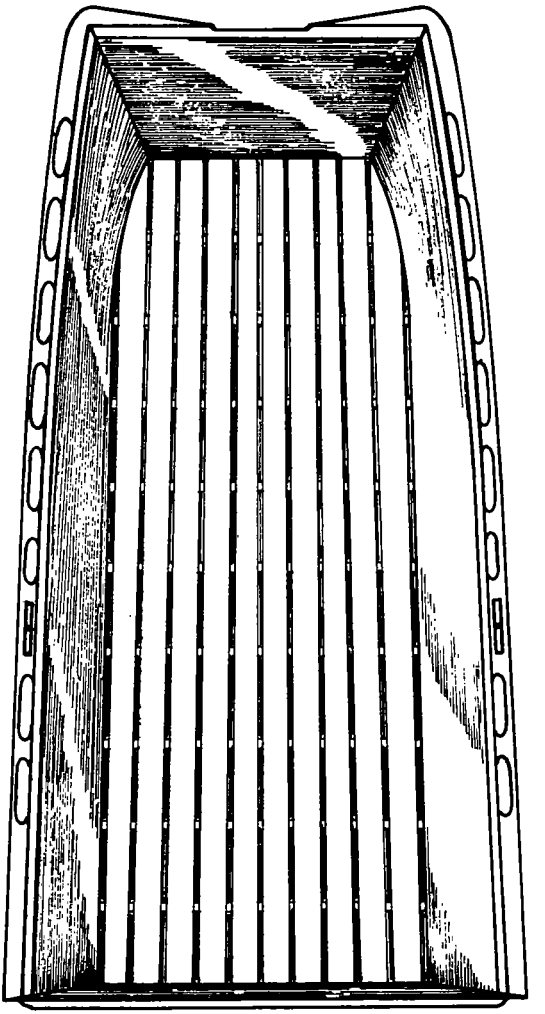


Figure 225. M2 assault boat.

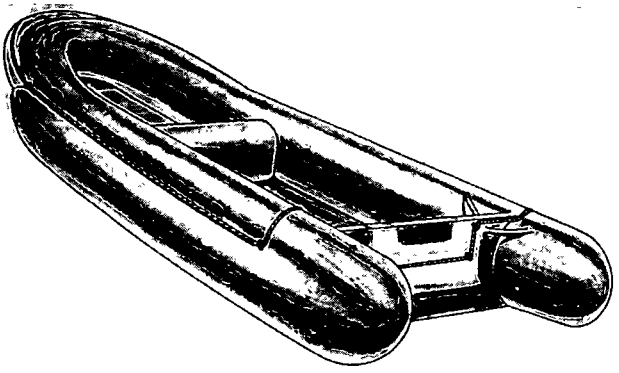


Figure 226. Fifteen-man pneumatic assault boat.

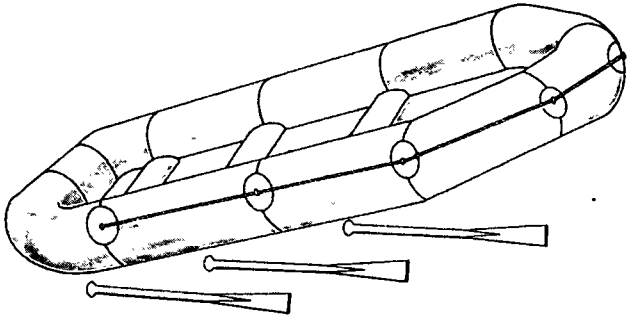


Figure 227. Three-man pneumatic reconnaissance boat.

coated nylon fabric. The boat is divided into 10 separate air compartments, 5 of which can be punctured and still carry a normal load of 15 men. There is little chance of noise caused by paddles touching the sides, making this boat ideal for silent crossings.

76. Three-Man Pneumatic Reconnaissance Boat

a. Use. The 3-man pneumatic reconnaissance boat (fig. 227) provides a lightweight portable means of transport for all reconnaissance activities where crossing of a water obstacle is necessary.

b. Design. The boat weighs 33 pounds complete with pump, paddles, repair kit, and carrying case. The boat is equipped with two oarlocks, towing rope, and a rope lifeline around the entire boat.

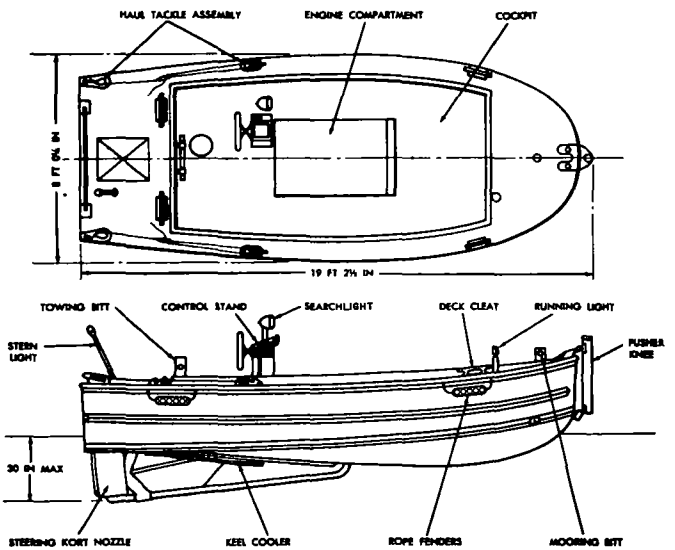


Figure 228. Design features, 19-foot bridge erection boat.

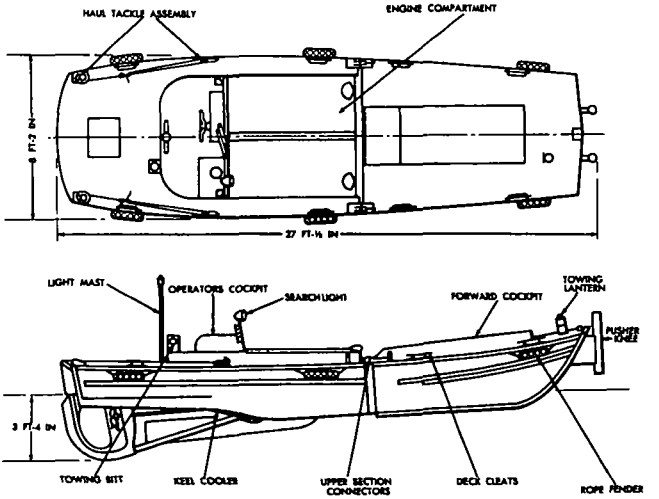


Figure 229. Design features, 27-foot bridge erection boat.

77. Bridge Erection Boat, 19-Foot

a. Design. The 19-foot bridge erection boat (fig. 228) is designed to assist in the assembly of tactical rafts. Only trained operators should operate the boat.

b. Propulsion. The boat is powered by a single inboard 6-cylinder marine type gasoline engine and carries a maximum allowable load of 3,000 pounds.

78. Bridge Erection Boat, 27-Foot

a. Use. The 27-foot bridge erection boat (fig. 229) or combinations thereof are capable of propelling the heaviest types of rafts assembled from

floating bridge sets. The load capacity of this boat is 3,000 pounds. When used to propel rafts, it is used as a pusher and is tied into the raft system with various types of pusher brackets and rope arrangements. Only trained powerboat operators should operate the boat.

b. Propulsion. The boat is powered by two separately controlled, inboard 6-cylinder marine gasoline engines. The boat has a two-section aluminum-alloy hull which can be disconnected for separate loading while transporting overland.

CHAPTER 11

EXPEDIENT ROAD AND HELIPAD CONSTRUCTION

79. Basic Considerations

In a theater of operations, routes of communication are of vital importance for movement of troops and supplies. In the combat area, when men, materials, equipment, or time are not available for more permanent type construction, expedient materials and methods may be used. With a choice of materials or methods, the determining factors in selecting the type of expedient to be used will be the time available for construction, the required permanency, and the anticipated type of traffic. As an expedient, any method or material that will provide a temporary road or helipad may be used.

80. Drainage

For expedient construction, seasonal consideration is very important. Even for short term usage, drainage may prove as important for expedient construction as for deliberate construction. The function of a drainage system is to remove all surface water from the operating areas, intercept and dispose of surface water from adjoining

areas, and remove the deterimental ground water seepage. When roads, airfields, or helipads must be constructed on a muddy base, drainage of the area should be concurrent with the expedient construction.

81. Landing Mats

The limited standard pierced steel plank (PSP) and pierced aluminum plank (PAP), which may still be encountered in the field, have been replaced by the standard types of landing mats, the M6 steel, M8 steel, and the M9 aluminum. Figure 230 shows landing mat used as road surface. Figure 231 shows a properly laid landing mat runway surface. TM 5–337 gives the complete details for the installation of landing mats for road and runway surfaces.

82. Wire Mesh

Chicken wire, chain-link wire mesh, and cyclone fencing are satisfactory expedients for roads and

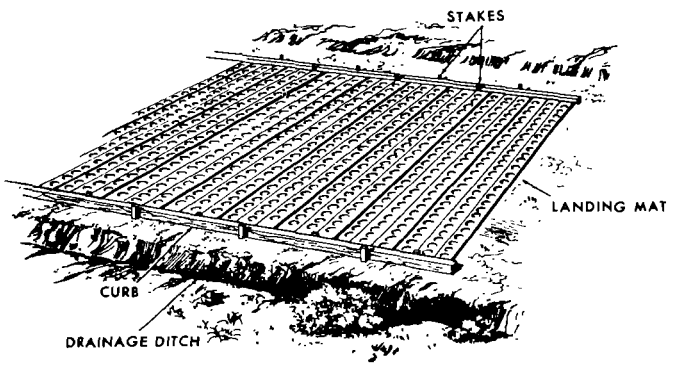
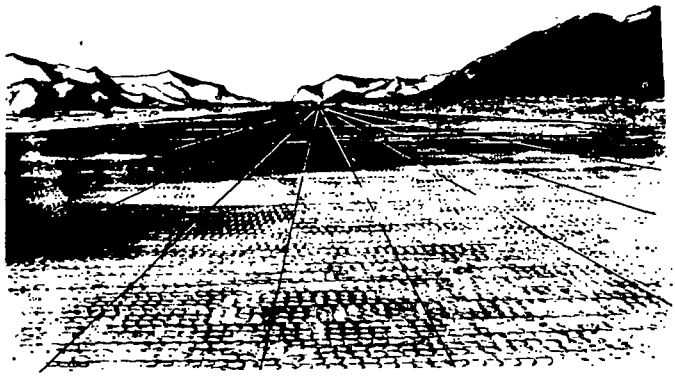


Figure 230. Landing mat road.



231. Landing mat runway.

helipads in sandy areas. They are unsatisfactory for muddy areas. The effectiveness of any one of the mesh-type expedients is greatly increased by the addition of a layer of burlap or similar type material to confine the sand. A sandwich type of construction, consisting of one layer of wire mesh, one of burlap, and a second layer of wire mesh is often used. The effectiveness of any type of wire mesh expedient depends on its being kept taut (fig. 232). A 3- to 10-gage strand of wire is threaded through the edges of the mesh and picketed down at about 1-meter intervals along its length. A hairpin type of picket (6.35-mm to 12.70-mm round steel bar, about 0.75m long, bent to shape) is desirable.

83. Army Track

To help vehicles in passing over loose sand and wet ground, a portable timber mat known as army

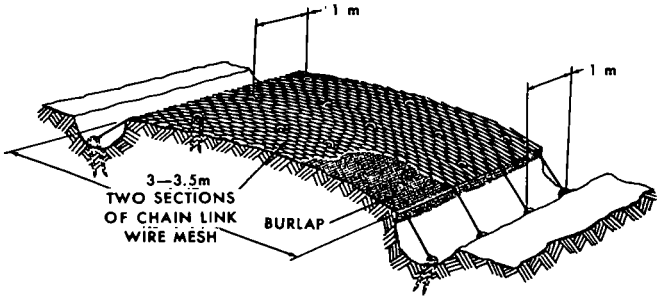


Figure 232. Construction details for wire mesh road.

track (or tread) may be used. It is prepared with 0.1m by 0.1m or 0.15m by 0.15m timbers, about 3 meters long, which are laced together with cable or threaded onto a cable which passes through holes near each end of the timber (fig. 233). To keep the timber spaced 0.3m, the holes are bored at an angle of 45° to the long axis of each timber. The cables are then securely anchored at each end. The track can be filled in between the timbers with the best material available to provide traction and a smoother riding surface.

84. Chespaling Mat

Chespaling mat roads are composed of a series of mats 2 by 3.5 meters, or larger. The mats are made by placing small saplings 2 meters long by 0.05 meters in diameter, 0.24 meters apart, and wiring them together with heavy smooth wire (fig. 234). A chespaling road is constructed by laying mats lengthwise with a 0.3-meter side over-

lap at the junction of the mats. The resulting surface is 3.7 meters wide. Unless laid on wet ground, this type of road requires periodic wetting down to retain its springiness and to prevent splitting. It also requires extensive maintenance.

85. Bamboo Mats

In some localities, bamboo mats may be fabricated and used for roads or helipads. The mats are made by splitting 0.05m bamboo rods and weaving them as shown in figure 235. The bamboo should be soaked before weaving and kept moist during use. On firm ground or sand, the mats remain serviceable for 3 or 4 months; on

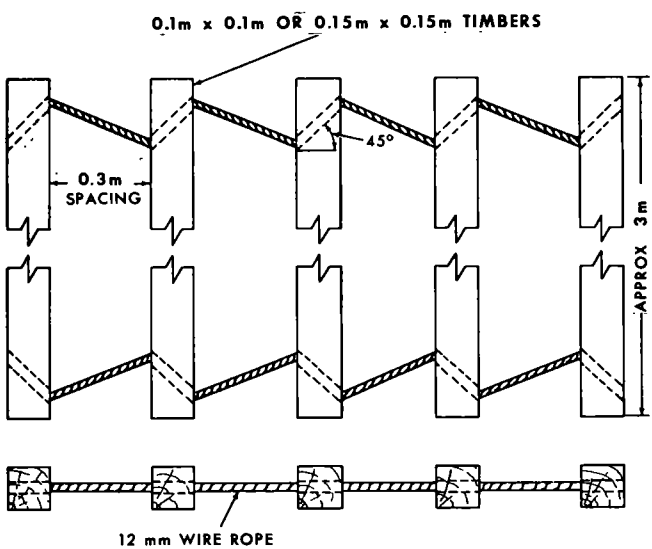


Figure 233. Army track.

Figure 234. Constructing chespaling mats.

muddy or unstable soil, they may pass 1,500 vehicles before becoming unserviceable. They are excellent for beach roadways and for ford exits. The mats are laid on the ground with the long dimension perpendicular to the direction of traffic

and are staked securely to the ground and adjacent mats are wired together

86. Plank Roads

Plank roads are used for crossing short sections of loose sand or wet soft ground. When well built with an adequate base, they last for many months. Planks, 0.08 to 0.10m thick, 0.2 to 0.3m wide, and at least 4 meters long, are desirable for flooring, stringers, and sleepers. Stringers are laid in regular rows parallel to the centerline on 1-meter centers, with the joints staggered. Floor planks are laid across the stringers with about 0.03m gaps to allow the timber to swell when it absorbs moisture. They are spiked to every stringer. Guardrails are placed on each side with a 0.3m gap

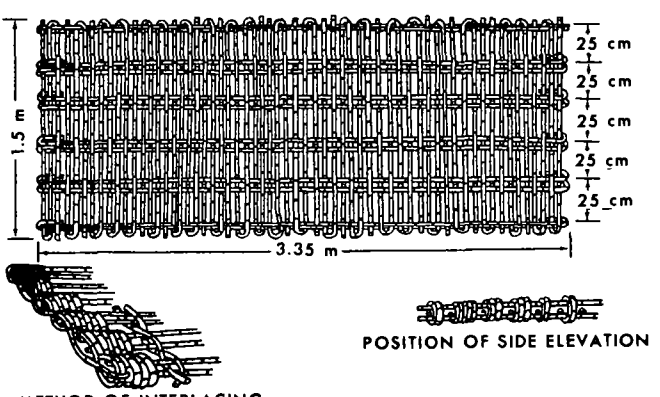


Figure 235. Construction details for bamboo mats.

between successive lengths of the guardrail for drainage of surface water. Pickets are placed along each side on 5-meter intervals to hold the road in alinement. For drainage, the base for a plank road is constructed with traverse slope instead of a center crown. To produce a smoother ride, treads are placed over the floor plank parallel to the line of traffic. Construction details are illustrated in figure 236.

87. Corduroy Roads

a. Types. Where timber is conveniently available, a corduroy road can be built over soft ground or muddy terrain. Corduroy roads are made of logs, split or round, laid across the centerline of the road. There are three general types of corduroy roads—

(1) Standard corduroy (cross logs laid directly on the ground).
(2) Corduroy with log stringers.
(3) Heavy corduroy (cross logs and stringers laid on sleepers).

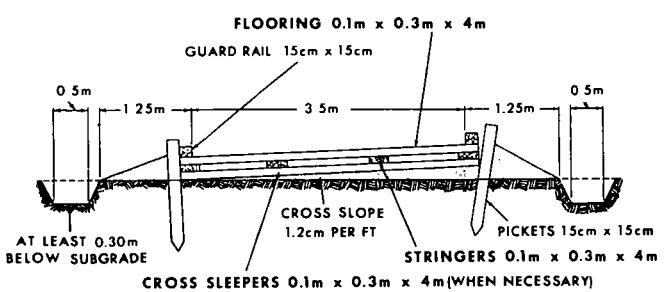


Figure 236. Construction details for plank road.

b. Construction.

(1) *Standard corduroy.* The most frequently constructed corduroy is the standard type. This type is constructed by placing logs 0.15 to 0.20m in diameter and 4 meters long adjacent to each other (butt to tip) perpendicular to the centerline of the roadway. Logs, 0.15m in diameter, placed along the edges to act as curbs and are wired or drift-pinned in place. Pickets about 1.25 meters long are driven into the ground at regular intervals along the outside of the corduroy to hold them in place. The chinks between the logs should be filled with branches, brush, and/or rubble and then covered with a layer of gravel or earth to provide a smoother surface. See figure 237 for a corduroy road under construction.

(2) *Corduroy with stringers.* A more substantial corduroy road can be made by placing log stringers parallel to the centerline on 1-meter centers and then laying the corduroy, as described above, over them. The corduroy decking is securely pinned to the stringers and then the surface is prepared as above (fig. 238).

(3) *Heavy corduroy.* Heavy corduroy is constructed by using a combination of sleepers and stringers with corduroy. The sleepers, 0.25 to 0.30m logs, are

Figure 237. Standard corduroy under construction.

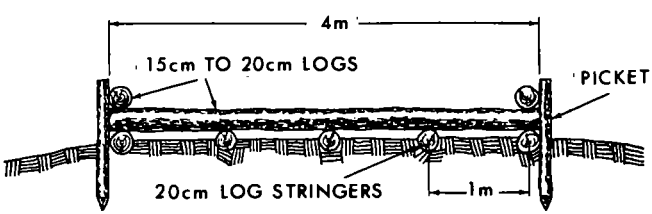


Figure 238. Corduroy with stringers.

placed at right angles to the centerline on 1.25-meter centers. On top of this, corduroy with stringers is constructed (fig. 239).

c. Selection of Type. The general rule for determining which type of corduroy to use in a given situation is, the softer the ground, the heavier the type of corduroy required. The stringers and sleepers do not increase the carrying capacity of the decking. They serve as a crib, keeping the road surface above the level of the surrounding mud, while sinking into the ground themselves until they reach a stable stratum.

88. Plank-Tread Roads

Plank-tread roads can be constructed easily and rapidly and require less material than ordinary plank roads discussed in paragraph 86. Construction details are shown in figure 240. Sleepers of 0.05m by 0.25m material, 4 to 5 meters long, are laid across the centerline for the road and embedded in the ground on approximately 3.5- to 5-meter centers. Spacing depends on the length

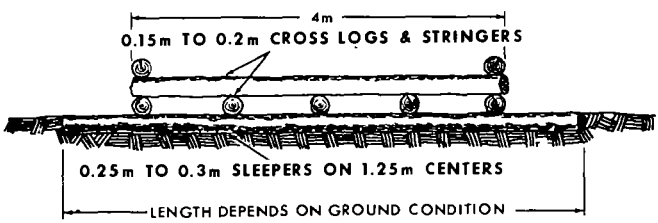


Figure 239. Heavy corduroy.

of plank available for tread; however, if the sleepers are thicker than 0.05m and/or hold the flooring too high off the ground, the spacing of the sleepers must be reduced as the flooring carrying the load will bend too much. Tread sections may be fabricated and laid directly from a truck bed to facilitate placement. Curbs normally are placed on the inside of each tread, sufficiently far apart

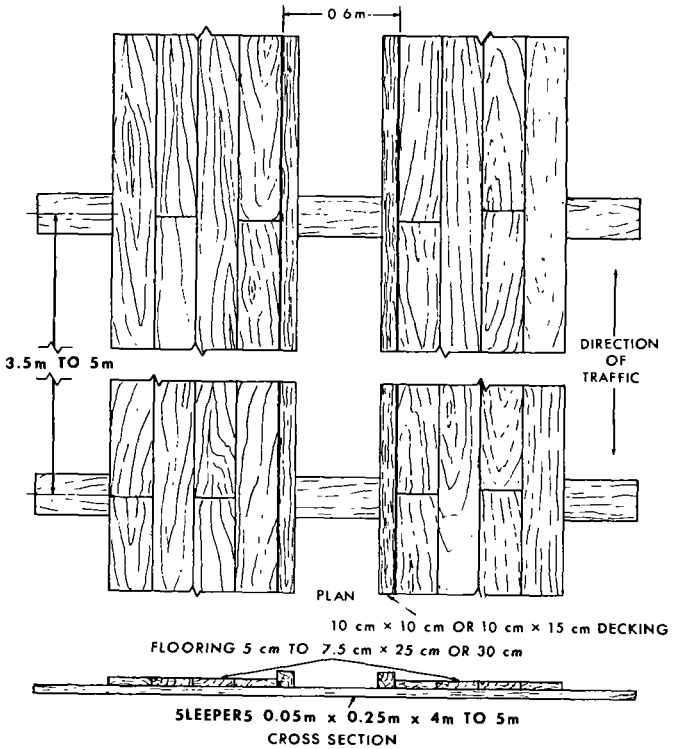


Figure 240. Construction details for plank tread road.

to allow clearance for the most narrow vehicle to use the road.

89. Helipads

In the construction of expedient type landing areas for helicopters, it may be necessary to construct elevated or raised platforms (figs. 241 and 242). Any of the procedures and methods used for expedient roads as described above can be easily adapted for helipad construction. In dry, dusty areas, a dust pallative is a must for helicopter operations of any duration. Tarpaulins, truck canvas, or plastic membrane materials will serve this purpose as an expedient. Extreme care must be taken to insure that the material is securely anchored to prevent it from rising in the rotor wash.

Figure 241. Helipad in mountainous, densely forested area.

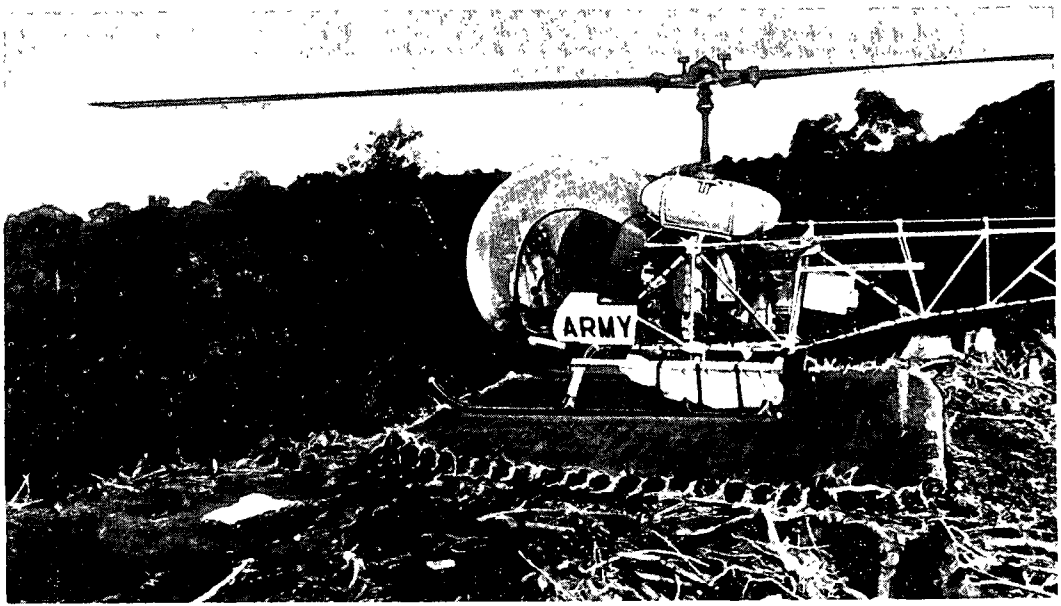


Figure 242. Helipad constructed of logs and covered with earth.

CHAPTER 12

GENERAL CONSTRUCTION

90. Introduction

This chapter is devoted to general construction practices normally used by engineer units. Standard and improvised or expedient types of construction are covered.

91. Nomenclature for Theater of Operations Frame Building

TO buildings are of many kinds as required by the function of the building, the local climate, the tactical situation, and the availability of various materials. The particular TO building shown in figure 243 is a typical example because its principal material is lumber which is generally available in most theaters. Figure 243 shows the building from the layout stage through the completed exterior. The nomenclature of the building is shown in the same general order as the actual construction sequence would proceed.

92. Joints, Splices, and Fasteners

a. Joints and Splices. The connections between pieces of wood are generally simple. When constructed properly, they are strong. As an engi-

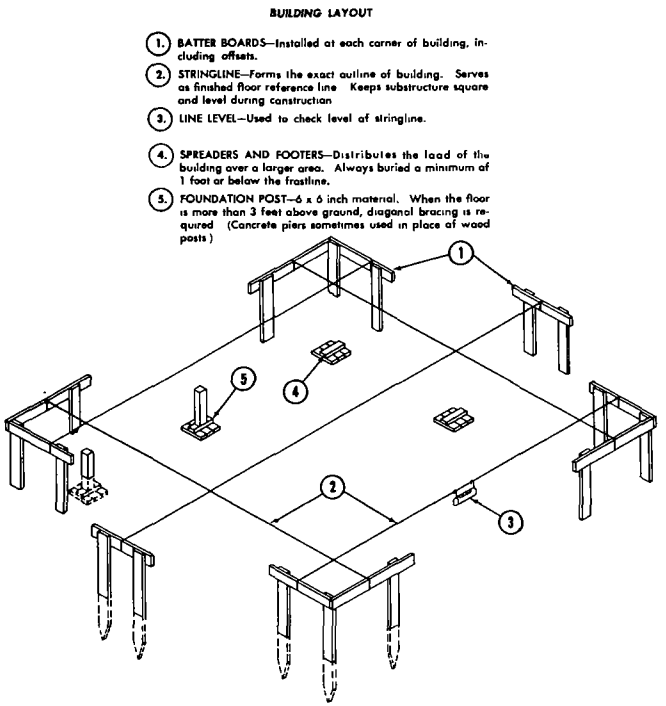


Figure 243. Steps in construction of a frame TO building.

neer soldier you must learn to make these connections accurately and quickly. All connections between pieces of timber are classified either as joints or splices. Joints (fig. 244) are connections between two pieces of timber which come together at an angle. Splices (fig. 245) are con-

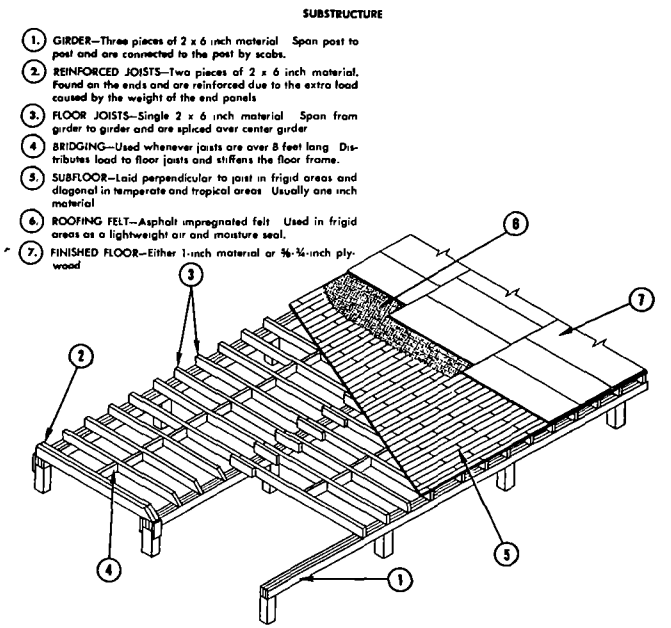


Figure 243—Continued.

nections between two pieces of timber which extend in the same line.

b. Fasteners. The fasteners used in the theater of operations are made of metal. These are classified as nails, screws, bolts, and corrugated fasteners.

(1) *Nails.* Nails are classified according to their use and form. All normal requirements for construction and framing fasteners are filled by one of the nail

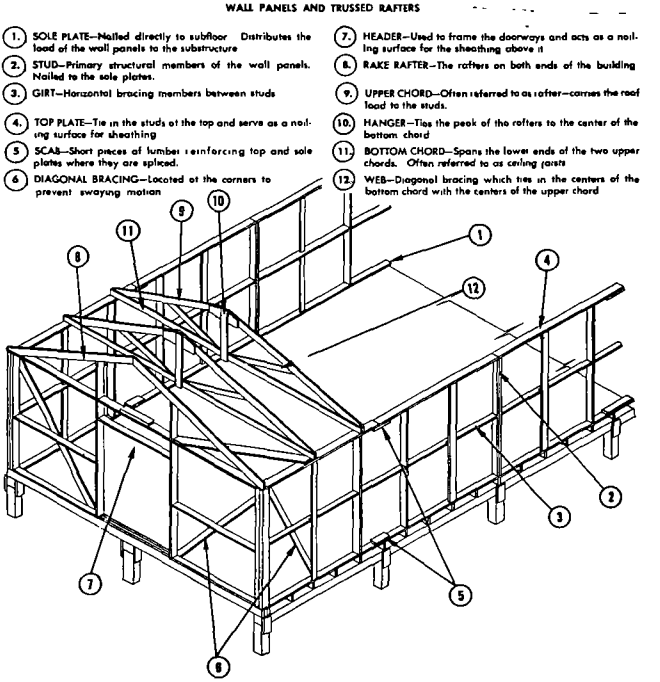


Figure 243—Continued.

types shown in figure 246. There are a few general rules to be followed in using nails as fasteners. When fastening two pieces of material of equal thickness together, the length of the nail should be 1½ times the thickness of one piece. They should be driven at an angle slightly toward each other to pro-

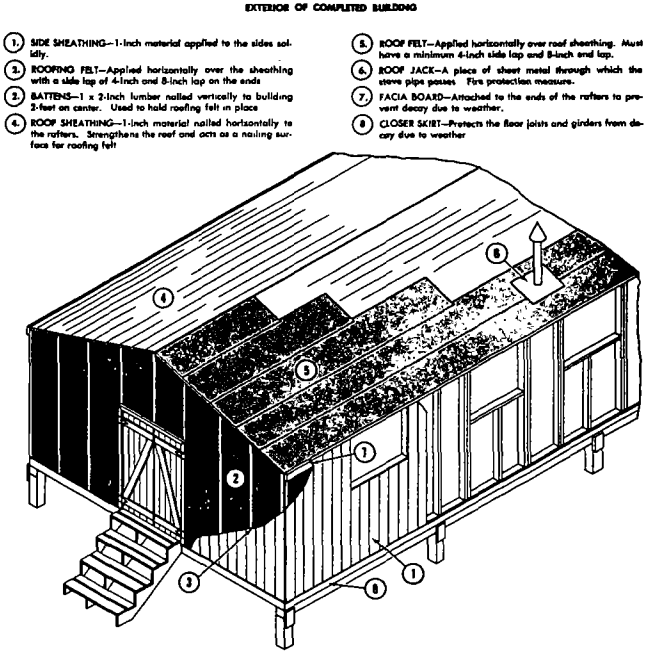
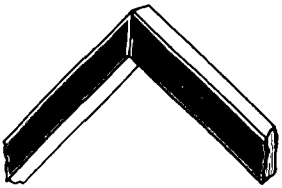


Figure 243—Continued.

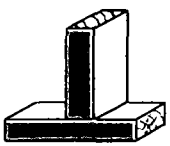
vide greater holding power. A few nails of proper type and size, properly placed and driven, will hold better than many nails driven close together.

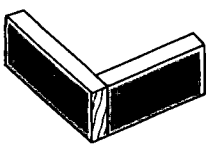
(2) *Screws.* The use of screws, rather than nails, is more expensive in terms of time and money but is often necessary to meet the requirement of higher hold-

BUTT JOINTS

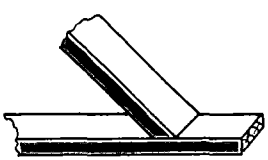


MITER BUTT JOINT. To form o right-ongle miter joint (the most commonly used), eoch piece is cut ot o 45° ongle. The miter butt joint is usuolly used ot corners where the stroight butt joint is not sotisfoctory.





STRAIGHT BUTT JOINTS. The butt end of one boord should be squore ond the foce of the other smooth so thot the pieces fit snug ond perpendiculor to eoch other. Noils or screws ore used to hold the pieces together. This type of joint is usuolly the weakest.



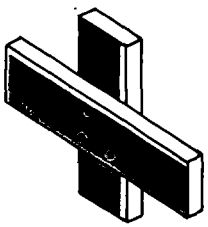
OBLIQUE BUTT JOINT. The type of joint is commonly used in brocing other pieces of timber. This joint should not be used where great strength is required.

Figure 244. Joints.

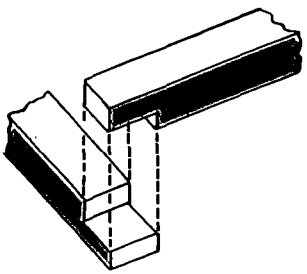
LAP JOINTS

The plain lap joint is the simplest and most often used method of joining in framing and construction. The joint constructed in this manner is as strong as the fasteners and material used.

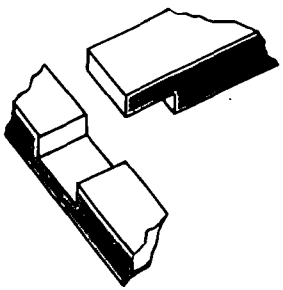
The half-lap joint is made by cutting away equal lengths and thicknesses from two boards and joining them so that the cut-away portions compliment each other in forming the joint. Surfaces must fit snugly and smoothly. Several useful variations of the half-lap are: cross lap and middle lap.



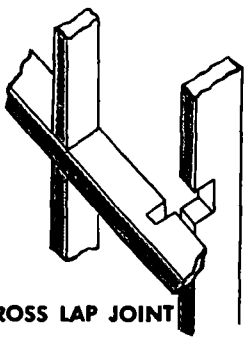
PLAIN LAP JOINT



HALF- LAP JOINT

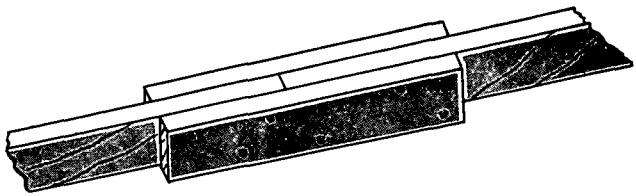


MIDDLE LAP JOINT

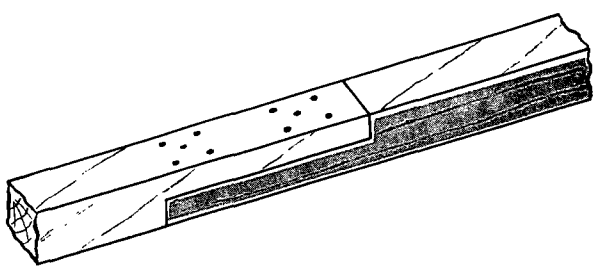


CROSS LAP JOINT

Figure 244—Continued.

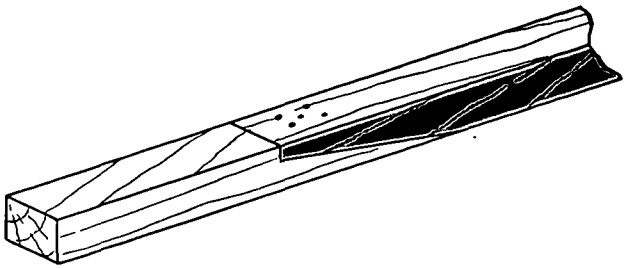


BUTT SPLICE. The butt splice is constructed by butting the squared ends of two pieces of timber together and securing them in this position by two short pieces of timbers (scabs) ar two metal plates (fish plates). Scabs are usually fastened with nails, while fishplates are fastened with bolts ar screws.

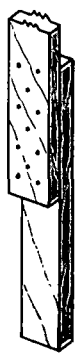


HALVED SPLICE. The halved splice is made by cutting away half the thickness of equal lengths fram two pieces of timber and fitting the complimentary tangues ar laps tagether. The laps should be long enough ta have good bearing surface. Nails ar balts may be used as fasteners. Scabs or fishplates may be used far added strength.

Figure 245. Splices.

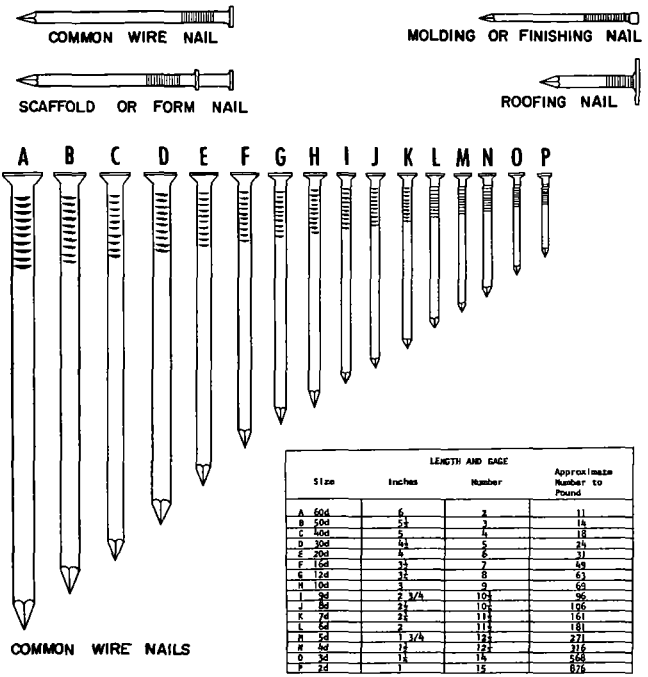


BEND RESISTANT SPLICE. This type of splice is used where it is necessary to splice horizontal members that support weight. A scab or fishplate may be fastened along the bottom of the splice to resist the tendency of the pieces to separate.



PLAIN SPLICE. The plain splice is the easiest and most common splice used in vertical timbers which require splicing. A long overlap of the two pieces is necessary to provide sufficient room for enough fasteners.

Figure 245—Continued.



LENGTH AND GAGE			
Size	Inches	Number	Approximate Number to Pound
A 60d	6	2	11
B 50d	5½	3	14
C 40d	5	4	18
D 30d	4½	5	24
E 20d	4	6	31
F 16d	3½	7	49
G 12d	3¼	8	63
H 10d	3	9	69
I 9d	2 3/4	10½	96
J 8d	2½	10½	106
K 7d	2½	11½	161
L 6d	2	11½	181
M 5d	1 3/4	12½	271
N 4d	1½	12½	316
O 3d	1¼	14	568
P 2d	1	15	876

Figure 246. Types of nails and nail sizes.

ing power. Wood screws are designated according to head style. The most common types are: flathead, ovalhead, roundhead, both in slotted and phillips heads (fig. 247).

(3) *Bolts.* Bolts are used in construction when great strength is required or when the work under construction must be frequently disassembled. Bolts are se-

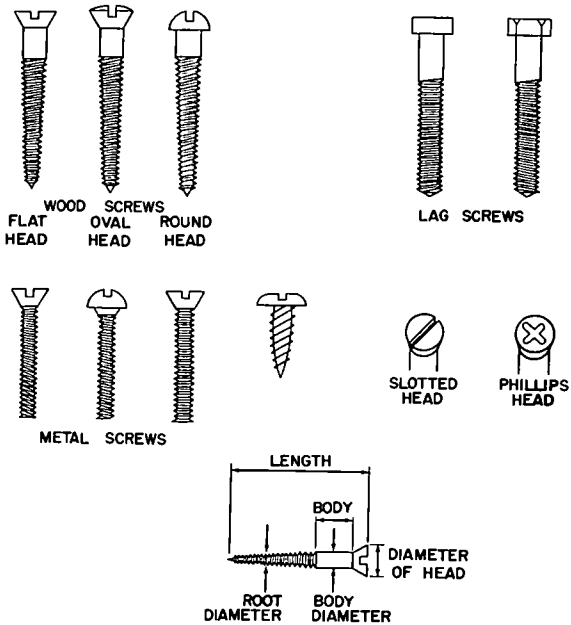


Figure 247. Types of screws.

lected for use in terms of length, diameter, style of head, and type (fig. 248). Proper selection of the type of bolt will result in good construction and appearance. The use of washers between the nut and the wood surface or between both the nut and the head and their opposing surfaces will avoid marring the surface and permit additional tightening.

(4) *Driftpins.* Driftpins are long, heavy, threadless bolts used to hold heavy pieces of timber together. The driftpins vary in diameter from ½ to 1 inch, and from 18 to 26 inches in length. To use a driftpin, a hole slightly smaller than the diameter of the pin is made in the timber and the pin is driven into the hole.

(5) *Corrugated fasteners.* The corrugated

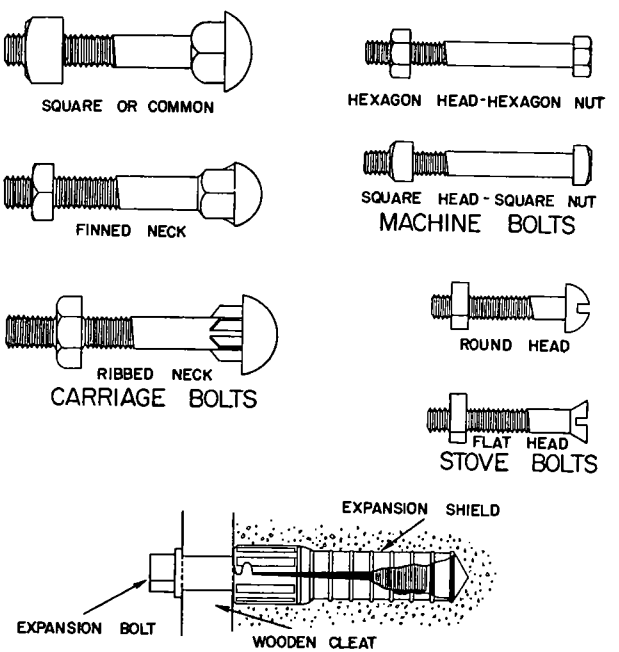


Figure 248. Types of bolts.

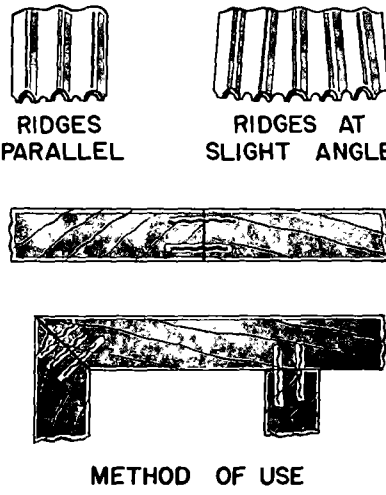


Figure 249. Corrugated fasteners and their uses.

fastener is one of the many means by which joints and splices are fastened in small timber and boards. It is particularly useful in a mitered joint. These fasteners are made in several different lengths and widths. The width varies from $\frac{5}{8}$ to $1\frac{1}{8}$ inches, while the length varies from $\frac{1}{4}$ to $\frac{3}{4}$ inches. The top or driving edge is cut square; the other end is sharpened with beveled edges. These fasteners have a greater holding power than nails in small timber. The proper method of using the fasteners is shown in figure 249.

93. Use of Native Materials

Engineers must be prepared to build facilities similar to native construction (straw roofs, bamboo framework, adobe) and to construct without such essentials as steel nails and driftpins. Mortise and tenon and dovetail joints, proper rigging techniques, and use of fasteners or other material can substitute for these devices. Figures 250 through 253 illustrate types of construction from the use of native materials. Helpful hints are outlined in figure 254 and precautions to follow are given in figure 255.

Figure 250. Split bamboo construction.

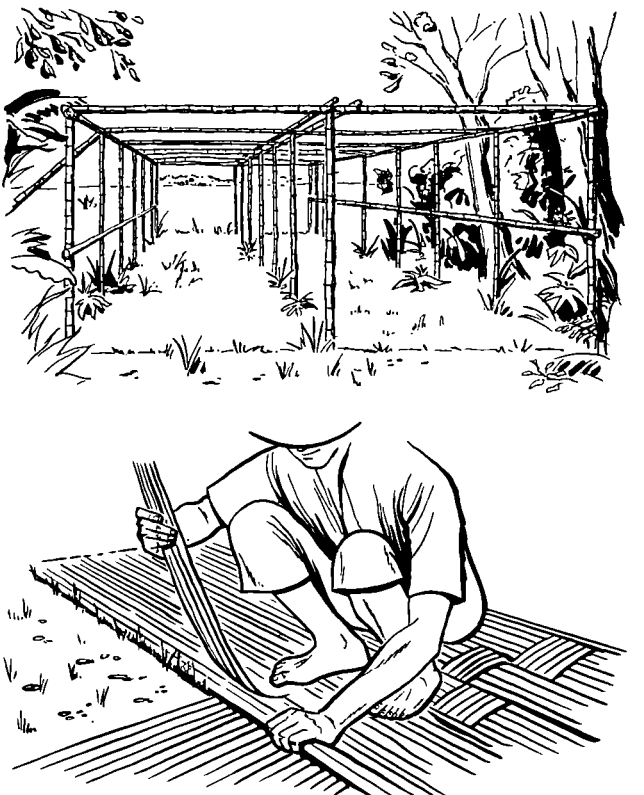


Figure 251. Bamboo pole and thatch construction.

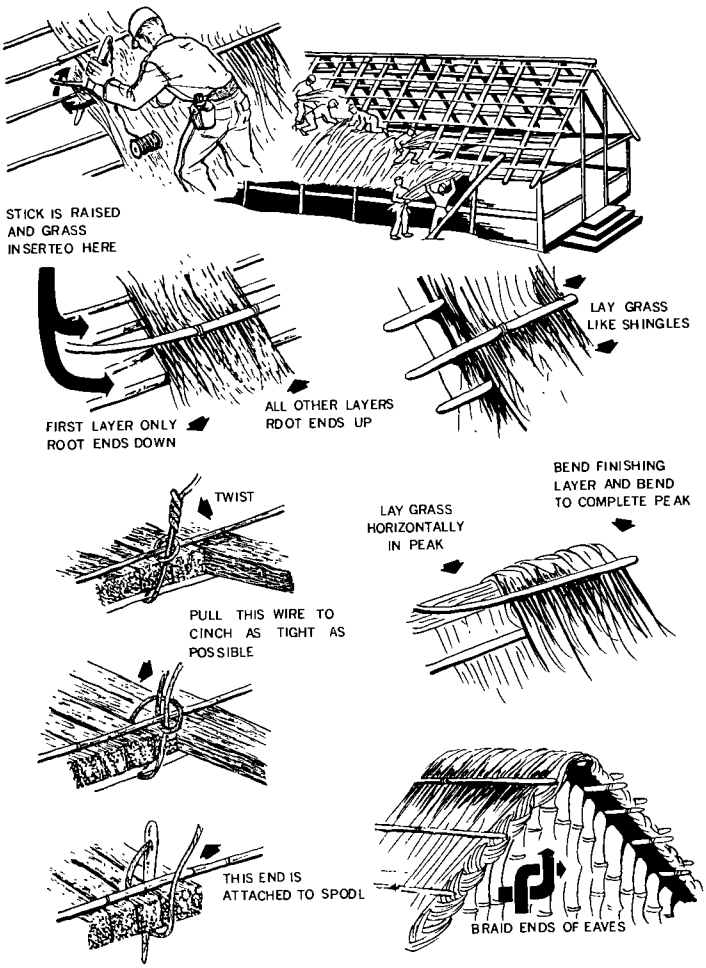


Figure 252. Details of grass thatching.

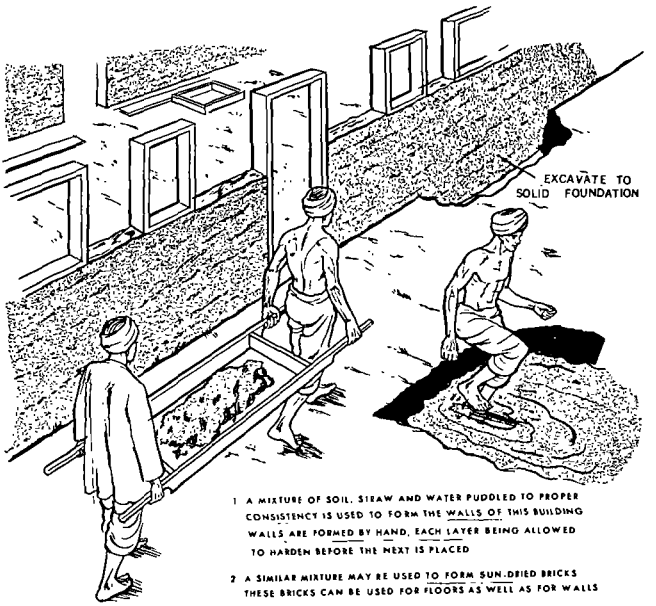


Figure 253. Adobe construction.

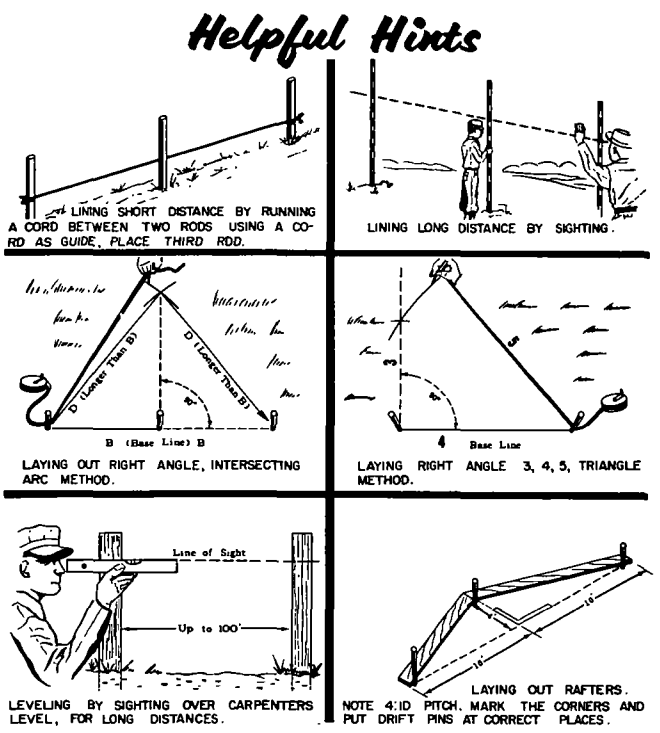


Figure 254. Helpful hints.

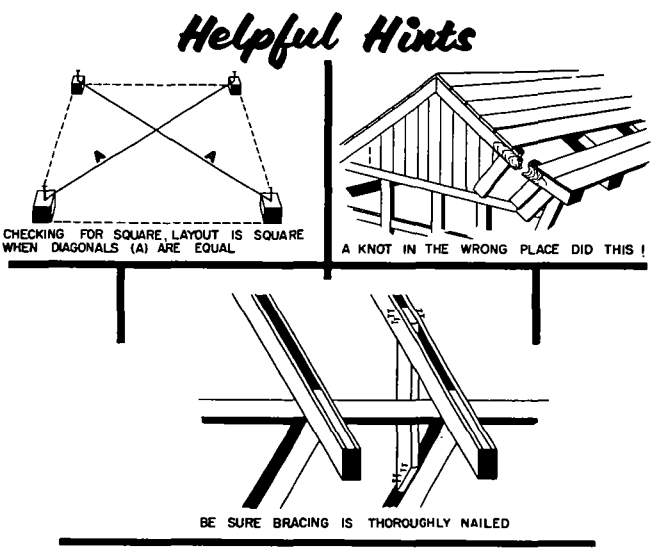


Figure 254—Continued.

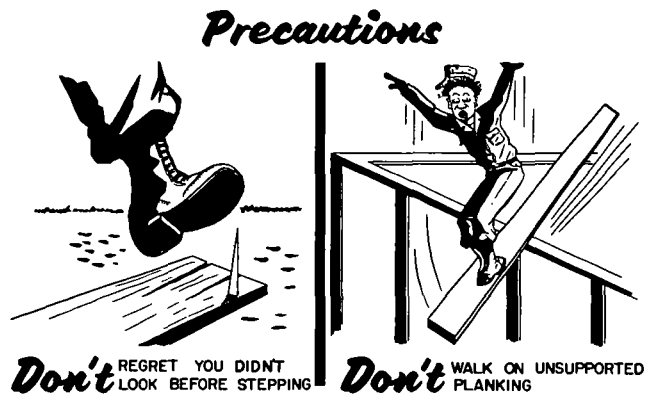


Figure 255. Precautions.

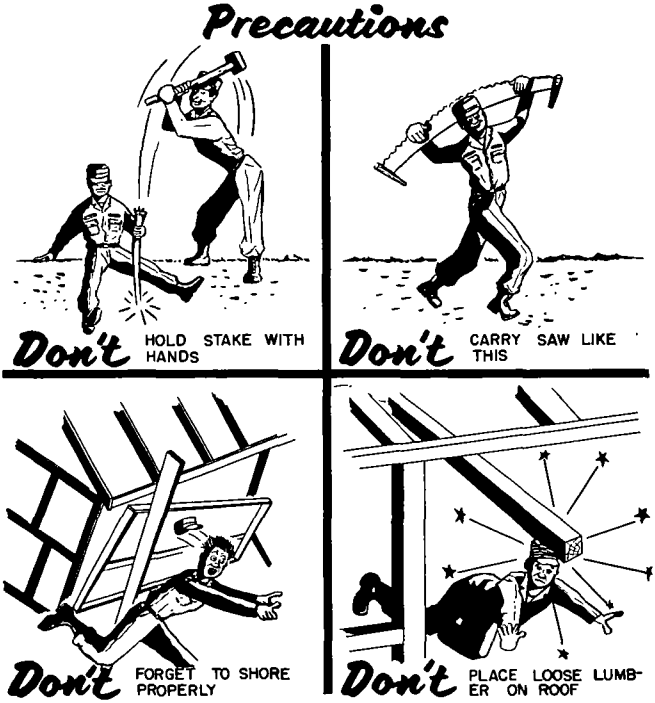


Figure 255--Continued.

CHAPTER 13

ENGINEER ROUTE AND ROAD RECONNAISSANCE

94. Introduction

This chapter provides basic information necessary for troops of all branches to understand the reconnaissance and classification system of existing routes of communication. A route describes an area of ground defined by specific limits over which movement is anticipated. It includes roads, bridges, tunnels, fords, and ferries that can be used in the transportation of troops and logistical support. A route may also contain navigable waterways, rails, and aircraft landing facilities.

95. Route Reconnaissance

Route reconnaissance is a special type of engineer reconnaissance. It is used to gain information which will aid in the selection of a route or routes to be used. It is usually made on the ground because of the need for close physical inspections of surfacing materials, bridging, drainage facilities, and stream bottom characteristics. Aerial reconnaissance is frequently used to supplement ground reconnaissance when practicable.

96. Recording Measurements

Measurements may be recorded in the metric system, the English system, or both. The measurement used must be clearly indicated, using universally known abbreviations such as "km" (kilometer), "m" (meter), "ft" (feet), and "mi" (miles).

97. Essential Information

Items of information of particular importance include, but are not necessarily limited to, the following items:

a. The nature of the terrain.

b. Existing roads and their physical characteristics such as length, width, gradient, and alinement.

c. Obstructions which may create bottlenecks or slow down movement. They are classified as natural or artificial—

(1) Natural obstructions include such features as watercourses, terrain compartments, wooded and jungle areas, swamp and flooded areas, and mountains.

(2) Artificial obstructions include such factors as nuclear radiation, built-up areas, tactical obstacles (minefields, barbed wire), low underpasses, narrow tunnels, narrow bridges, and other man-made features.

98. Route Reconnaissance Report

The route reconnaissance report should be accurate, clear, and concise. The method generally

preferred for this report is in the form of a simplified map (fig. 256), using symbols (fig. 257) to indicate the limiting features. This report is accompanied by a road reconnaissance report (fig. 258) and is further supported by military sketches, photographs, and local maps.

99. Checklist

A checklist for use in obtaining the data from which to prepare a route reconnaissance report

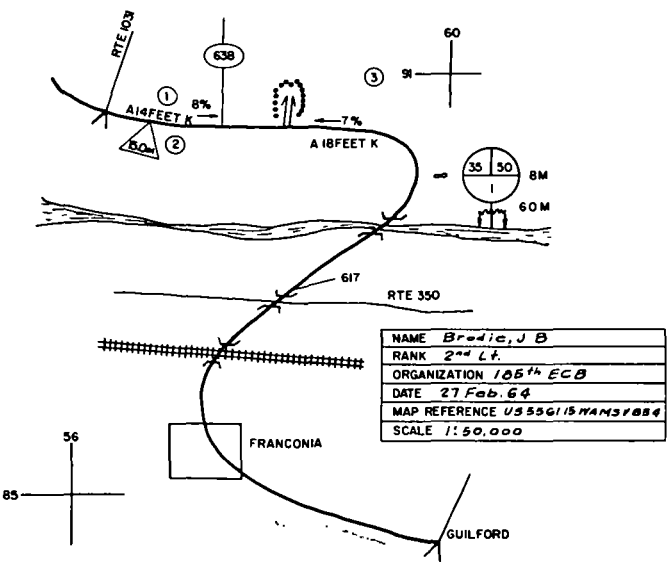


Figure 256. Example of a route reconnaissance report.

SYMBOL	DESCRIPTION & CRITERIA	ITEM CONSIDERED AN OBSTRUCTION (Impedes Flow of Traffic)
	SHARP CURVE (Radius Less Than 30 Meters)	(ob)
	STEEP GRADE (Arrows Point Uphill) (Grade In Percent) (Length Of Arrows May Show Length Of Grade When Scale Allows) 7% Or Greater	(ob)
	CONSTRUCTION (Width Of Usable Road In Meters)	(ob)
	ARCH CONSTRUCTION (Width On Left And Height On Right In Meters)	WHEN LESS THAN REQUIRED CLEARANCES
	UNDERPASS (Width On Left And Height On Right In Meters)	
	BYPASS EASY	
	BYPASS DIFFICULT	
	BYPASS IMPOSSIBLE	
	LEVEL GRADE CROSSING (RR)	(ab)
	FORD	(ob)
	FERRY	(ob)
	TUNNEL	WHEN LESS THAN REQUIRED CLEARANCES
	LIMITS OF SECTOR	
(617)	CIVIL OR MILITARY ROUTE DESIGNATION	
	COVER (Deciduous Wood) ARROW DENOTES DRIVING OFF ROAD INTO DECIDUOUS WOOD	
	COVER (Evergreen Woods)	
	POSSIBLE WATERPOINT	
	WATERPOINT IN OPERATION	

Figure 257. Symbols used in the route reconnaissance report.

is listed below and illustrated in figures 256 and 257.

a. Length between well-marked points, in

either miles or kilometers and decimal fractions thereof may be shown.

b. Curves having a radius of less than 100 feet (30 m.), each with its radius in feet or meters.

c. Steep grades, each with its maximum gradient in percent and length of any grade of 6 percent or greater.

d. The road width of constructions, each with the width of its traveled way in feet or meters, and its length in either miles or kilometers and decimal fractions thereof.

e. Underpass limitations, each with its limiting height and width in feet or meters.

f. Bridge bypasses, each classified as easy, difficult, or impossible.

g. Civil or military road numbers or other designation.

h. Cover and/or concealment suitable for parking and camouflage.

i. Feasibility of driving off the road, including shoulders.

j. Location of fords and ferries, including limited information.

100. Road Reconnaissance

Road reconnaissance is a specific type of route reconnaissance and is performed to determine the conditions of existing roads for immediate use. The information obtained from road reconnaissance is used to estimate the quantity and kind of traffic and loads that a road can carry in its present condition.

101. Required Information

Information required for the reconnaissance report of an existing road includes the following:

a. Local name of the road.

b. Local road designation and number.

c. Location of the road by map grid reference.

d. The length of the road between specified and readily identifiable points.

e. The normal width of the road—

(1) Between fences.

(2) Between drainage ditches.

(3) Between edges of the pavement (traveled way).

f. Alinement of the road.

g. Drainage, including culverts.

h. Foundation.

i. Surface.

j. Obstructions, including kinds and locations.

k. Reduction in width.

l. Excessive gradients; locations and grades of all gradients steeper than 6 percent.

m. Sharp curves (radius shorter than 100 feet or 30 meters).

n. Bridge locations.

o. Underpass locations showing length, width, and height.

p. Tunnel locations showing length, width, and height.

q. Ford locations.

r. Ferry locations.

102. Road Classification Formula

The road classification, as shown on the back of the standard road reconnaissance form (fig. 258), is expressed by a basic formula, using symbol systems. The characteristics of the road will be expressed in accordance with prescribed definitions and symbols in the following order: limiting factors, width, and construction material.

a. Limiting Factors. The formula will be prefixed by the symbol "A" if there are no *limiting factors,* and by the symbol "B" if there are *one or more limiting factors.* If a limiting factor is unknown, it will be expressed by a question mark inclosed in parentheses, as (?). The criteria for determining the limiting factors and the symbols used are shown in table II.

b. Width. The width of the road (traveled way) is expressed in feet or meters followed by a "slash" and the width of the traveled way and the shoulders combined as 14/16 feet.

c. Road Construction Materials. Road construction materials are also expressed by a symbol system. Symbols to be used for this purpose are listed in table III.

d. Examples of Road Classification Formula. Correct usage and proper order of presentation of information is illustrated in the following examples:

(1) *A 5.0/6.2 m k.* This formula describes a concrete surface road with a traveled way 5.0 meters wide and a combined width of traveled way and shoulders of 6.2 meters. This road has no limiting factors.

Table II. Criteria for Determination of Limiting Factors

Limiting factor	Criteria	Symbol
Sharp curves _____	Sharp curves with radius less than 100 feet (30 meters) cause some slowing of convoy traffic and will in addition be reported as obstructions.	c
Steep gradients___	Steep gradients, 6% or steeper, cause some slowing of convoy traffic. Gradients steeper than 6% and excessive changes in gradients will also be reported as obstructions.	g
Poor drainage_____	Inadequate ditches, crown/camber, or culverts; culverts and ditches blocked or otherwise in poor condition.	d
Weak foundation__	Unstable, loose or easily displaced material.	f
Rough surface____	Bumpy, rutted or potholed to an extent likely to reduce convoy speeds.	s
Excessive camber or superelevation.	Falling away so sharply as to cause heavy vehicles to skid or drag toward the roadside.	j

(2) *Bgs 14/16 ft. 1 (Ob).* This formula describes a gravel or lightly metalled surface road with a traveled way 14 feet wide and a combined width of traveled way and shoulders of 16 feet. This road has steep gradients, a rough surface, and obstructions.

103. Road Reconnaissance Report

a. A road reconnaissance report contains all of the necessary information required for the classification of a road. Characteristics of any given road may change considerably in relatively short distances. Because of these many changes, the reconnaissance report may require the use of several copies of the reporting form, each covering a selected section of the road.

b. The Road Reconnaissance Report (DA Form 1248, fig. 258) is used to report the gathered information. When it is impossible to determine any item required by the report, the appropriate space should be marked NOT KNOWN. If the data for items 9, 10, 11, and 12 of the form are different for various stretches of road, they should be indicated by placing the appropriate road classification formula (par. 102) on the mileage chart opposite the stretch of road to which the classification applies. The mileage chart is on the reverse side of the form. If the English system of measurement (miles, yards, feet) is used, the opposite metric side of the chart may be used for additional information and vice versa if the metric system is used.

Table III. Symbols for Types of Surface Materials

Symbol	Material	Normal road type	
k	Concrete	Type (X); generally heavy duty	X
kb	Bituminous or asphaltic concrete (Bituminous plant mix).	Type (X); generally heavy duty	X
p	Paving brick or stone	Type (X); generally heavy duty	X
rb	Bitumen penetrated macadam waterbound macadam with superficial asphalt or tar cover.	Type (X); or type (Y); generally medium duty	Y
r	Waterbound macadam, crushed rock or coral.	Type (Y); generally light duty	Y
l	Gravel or lightly metalled surface	Type (Y); generally light duty	Y
nb	Bituminous surface treatment on natural earth, stabilized soil, sand-clay or other select material.	Type (Y) or (Z); generally light duty	Y
n	Natural earth stabilized soil, sand-clay, shell, cinders, disintegrated granite or other select material.	Type (Z); generally light duty	Z
v	Various other types not mentioned above.	(Indicate length when this symbol is used.)	Z

In addition to the symbols shown above, the symbol "b" (bituminous surface) may be used alone when the type of bituminous construction cannot be determined.

ROAD RECONNAISSANCE REPORT (FM 5-36)

DATE: 27 February 1964

TO (Headquarters ordering reconnaissance): S-2 185th ECB

FROM (Name, grade and unit of officer or NCO making reconnaissance): 2nd Lt. John B. Brodie, 185th ECB

1. MAPS	a. COUNTY	b. SCALE	c. SHEET NUMBER OR NAME	d. DATE/TIME GROUP (Of information)
	Virginia, Allendale	1:50000	US Sheet 3361 15 W AMS V834	271530Z

SECTION I - GENERAL ROAD INFORMATION

2. ROAD GRID REFERENCE		4. ROAD NUMBERING (Civilian or Military number of road)	5. LENGTH OF ROAD (Miles or kilometers, specify)
FROM	TO		
305034-294100	315060-294250	Fairfax 644	6.7 Miles
6. WIDTH OF ROADWAY (Feet or meters, specify)		8. WEATHER DURING RECONNAISSANCE (Include last rainfall, if known)	
14-30 Feet		Cold, dry, 31° F, Last rain 26 February 1964	
7. RECONNAISSANCE			
DATE: 27 February 1964	TIME: 0800-1200		

SECTION II - DETAILED ROAD INFORMATION (When circumstances permit more detailed information will be shown in an overlay or on the mileage chart on the reverse side of this form. Standard symbols will be used.)

9. ALINEMENT (Check one ONLY)

- [ ] (1) FLAT GRADIENTS AND EASY CURVES
- [ ] (2) STEEP GRADIENTS (8 percent or 7 in 100)
- [ ] (3) SHARP CURVES (Radius less than 100 ft (30m))
- [x] (4) STEEP GRADIENTS AND SHARP CURVES

10. DRAINAGE (Check one ONLY)

- [x] (1) ADEQUATE DITCHES, CROWN/CAMBER WITH ADEQUATE CULVERTS IN GOOD CONDITION
- [ ] (2) INADEQUATE DITCHES, CROWN/CAMBER OR CULVERTS. ITS CULVERTS OR DITCHES ARE BLOCKED OR OTHERWISE IN POOR CONDITION

11. FOUNDATION (Check one ONLY)

- [x] (1) STABILISED COMPACT MATERIAL OF GOOD QUALITY
- [ ] (2) UNSTABLE, LOOSE OR EASILY DISPLACED MATERIAL

12. SURFACE DESCRIPTION (Complete items 12a and b)

a. THE SURFACE IS (Check one ONLY)

- [x] (1) FREE OF POTHOLES, RUTS, OR RUTS LIKELY TO REDUCE CONVOY SPEED
- [ ] (2) RUTTED OR POTHOLED TO AN EXTENT LIKELY TO REDUCE CONVOY SPEED

b. TYPE OF SURFACE (Check one ONLY)

- [ ] (1) CONCRETE
- [x] (2) BITUMINOUS (Specify type where known): See mileage chart
- [ ] (3) BRICK (Pave)
- [ ] (4) STONE (Pave)
- [ ] (5) CRUSHED ROCK OR CORAL
- [ ] (6) RAVEL
- [ ] (7) GRAVEL
- [ ] (8) LIGHTLY METALLED
- [ ] (9) NATURAL OR STABILISED SOIL, SAND CLAY SHELL, CINDERS, DISINTEGRATED GRANITE, OR OTHER SELECTED MATERIAL
- [ ] (10) OTHER (Describe):

SECTION III - OBSTRUCTIONS (List in the columns below continuance of the following obstructions which affect the traffic capacity of a road. If information of any factor cannot be ascertained, insert "NOT KNOWN")

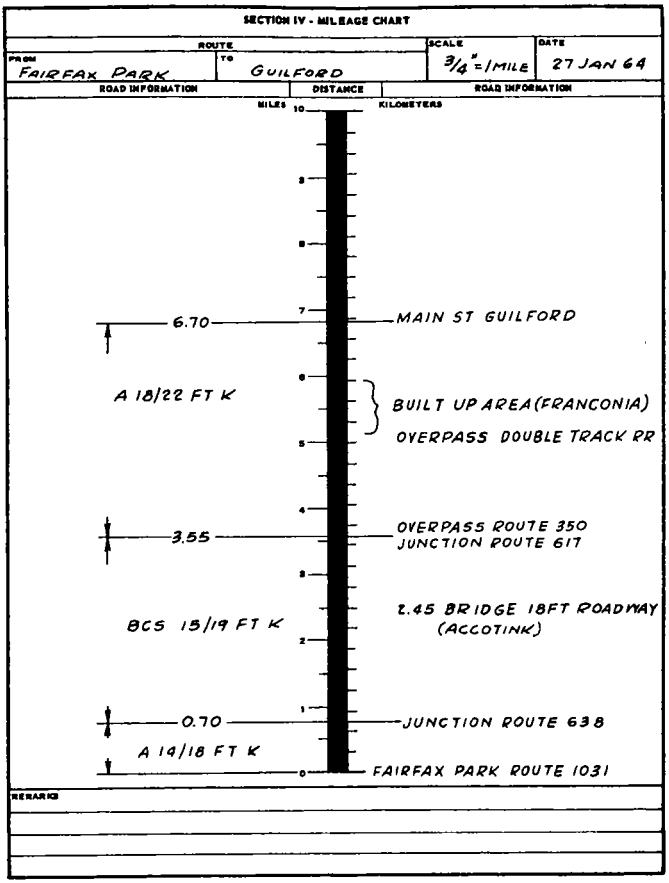
(a) Overhead obstructions, less than 14 feet or 4.25 meters, such as tunnels, bridges, overhead wires and overhanging buildings.
(b) Reductions in road widths which limit the traffic capacity, such as culverts, narrow bridges, embankments, and buildings.
(c) Excessive gradients (Above 7 in 100)
(d) Curves less than 100 feet (30 meters) in radius
(e) Fords

SERIAL NUMBER	PARTICULARS	GRID REFERENCE	REMARKS
a	b	c	d
1	Steep grade - 8% uphill going East, .02 miles long	305300-294250	
2	Series of sharp curves	305300-294250 TO 305500-294200	
3	Steep grade - 7% down hill going east	308000-293850	

DA FORM 1 JUL 56 1248 PREVIOUS EDITION OF THIS FORM IS OBSOLETE.

Front

Figure 258. Example of a standard road reconnaissance form.



Back

Figure 258—Continued.

CHAPTER 14

SURVIVAL

104. Basic Survival Knowledge

Modern combat increases the likelihood of becoming isolated and having to find water, food, and shelter for many days—even weeks. The ability to evade the enemy and to escape if captured are both basic requirements of the soldier's Code of Conduct and demand every survival skill you can master. Even in peacetime, the chances of being exposed to such an emergency are always present, especially when traveling either by land, sea, or air. Always expect the unexpected—to be placed in a survival situation at any time and be ready to meet survival problems in any environment in which you may be stranded. Therefore, the purpose of this chapter is to anticipate the unexpected and to be prepared to survive.

105. Individual and Group Survival

Whether isolated in a group or alone, you will experience emotional problems resulting from fear, despair, loneliness, and boredom. In addition to these mental hazards, injury and pain, fatigue, hunger, or thirst tax your will to live. If you are not prepared mentally to overcome all

obstacles and accept the worst, the chances of surviving are greatly reduced. Remember the lesson that servicemen isolated during World War II and the Korean Conflict learned—survival is largely a matter of *mental outlook* with the *will* to survive.

a. Individual Survival. The feeling of loneliness, helplessness, and despair, which is experienced by individuals when isolated or captured, can be reduced or even avoided if you remember the keyword S-U-R-V-I-V-A-L.

b. Group Survival. Groups, such as squads or platoons that work together and have leaders that fulfill their responsibilities, have the best chance of survival. Even if your group is newly formed, these simple rules will assure that it will function at it best.

(1) *Organize.* The leader will organize the group and seek out individual skills to support the group plan. If one man feels he can fish better than cook, he should be assigned the job of providing fish. Your active cooperation in volunteering your services will make the group function more effectively.

(2) *Lead your men.* You may find that your rank and position in the group qualifies you as the leader. If so—take charge. Never leave leadership up to chance acceptance by some member after a situation arises. Know yourself and your

Size the situation by considering YOURSELF, THE COUNTRY, and THE ENEMY. Recognizing your limitations and abilities and formulating a plan by observing the country and the enemy is the first step in survival.

Undue haste makes waste. Being too eager, impatient, or losing your temper are the danger signals to stop and collect your thoughts before committing a foolish act.

Remember where you are. Do not begin immediately to wander aimlessly about the countryside. Take time to discover your location or the general direction you want to travel; i.e. North, South, etc.

Vanquish fear and panic. Fear is normal and necessary; it gives you that extra shot of energy when needed. It causes you to be extra sensitive to your surroundings. Recognize your fear and use it to your advantage.

Improvise. Remember, no matter how bad things are, you can do something to improve the situation. Figure out what you need; take stock of what you have; then improvise.

Value living. Hope, a real plan for survival, and concentrsting on getting out alive all reduce fear and make chances of survival better.

Act like the natives. Observing native behavior and copying their way of living will aid you in surviving and escaping through enemy territory. "Go native" and avoid attracting attention to yourself.

Learn basic skills. Make sure you learn the skills of firemaking, food and water identification, shelter construction, and navigation so thoroughly that they become automatic. Be inquisitive and search for additional survival knowledge.

men and be responsible for their welfare.

(3) *Develop mutual dependence.* Each man is dependent on the other men for survival and must receive support and strength from the other men. Each member must do his part.

(4) *Respect the leader's decisions.* In addition to taking care of himself, the leader has the responsibility of the survival of the group. A good leader will seek advice and recommendations; support him in every way.

(5) *Think.* Consider the facts and make decisions rapidly. Not only is this essential of the leader, but of each member of the group. The ability to think quickly will contribute materially to survival success.

106. Health and First Aid

If you are alone, you must rely on yourself to keep in good physical condition. If you are a member of a group, your ability to keep healthy and care for yourself and others will greatly increase your chance of surviving. Practice the following health and first aid procedures outlined in figures 259 and 260; your life may depend on them some day!

107. Orientation and Traveling

The first survival problems you must solve are determining where you are, in what direction you must go, and how to travel to reach civilization. The following graphic illustrations (figs. 261 and 262) will help solve these problems.

108. Firemaking and Cooking

Fire will be needed for warmth, keeping dry, signaling, cooking, and for purifying water by

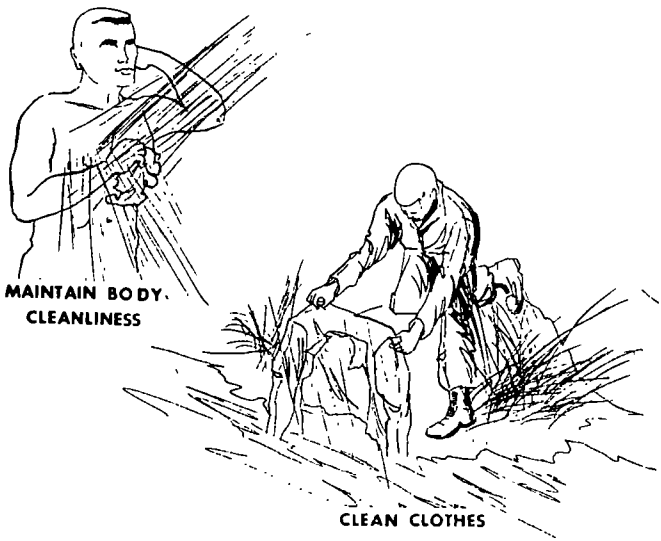


Figure 259. Health aids.

boiling. Cooking foods will make them more tasty, digestible, and free from bacteria, toxins, and harmful plant and animal products. Extreme care and common sense must be exercised in firemaking when operating in or near an enemy held area. The illustrations (figs. 263 through 265) that follow only scratch the surface on firemaking and cooking techniques. Your own resourcefulness will discover additional methods.

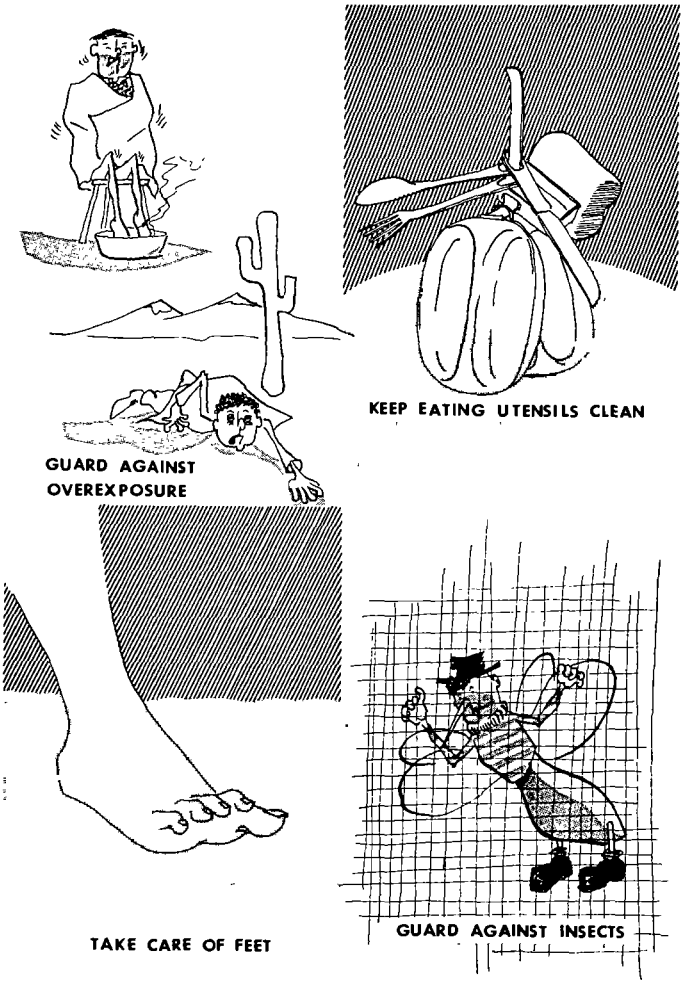


Figure 259—Continued.

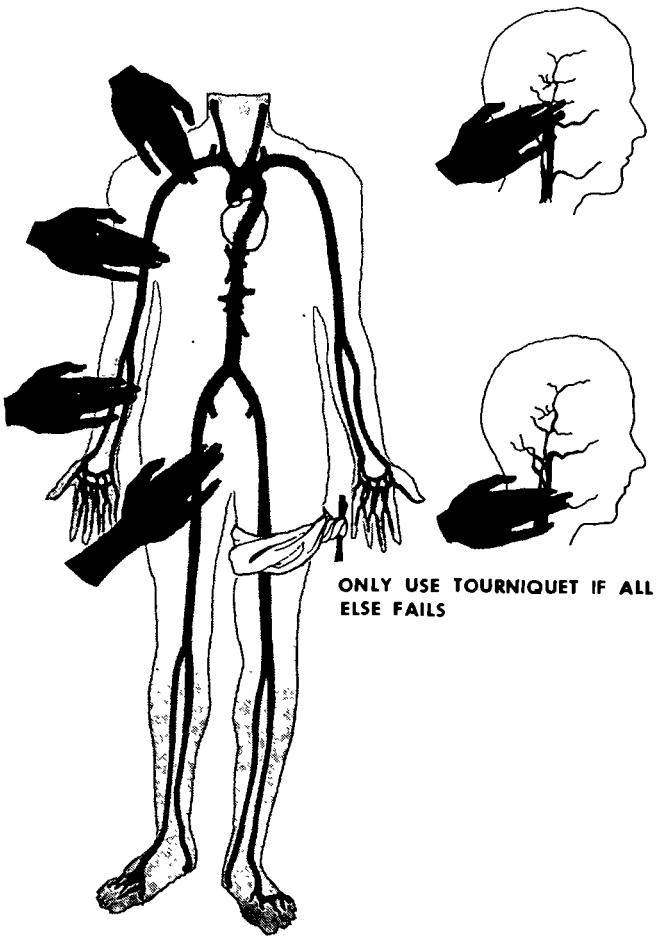


Figure 260. Survival first aid.

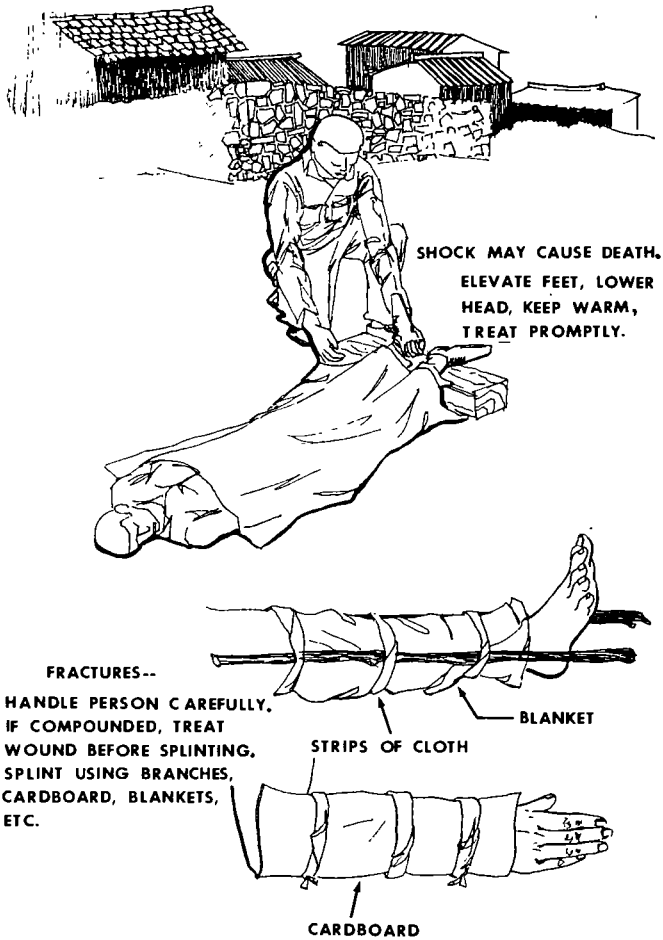


Figure 260—Continued.

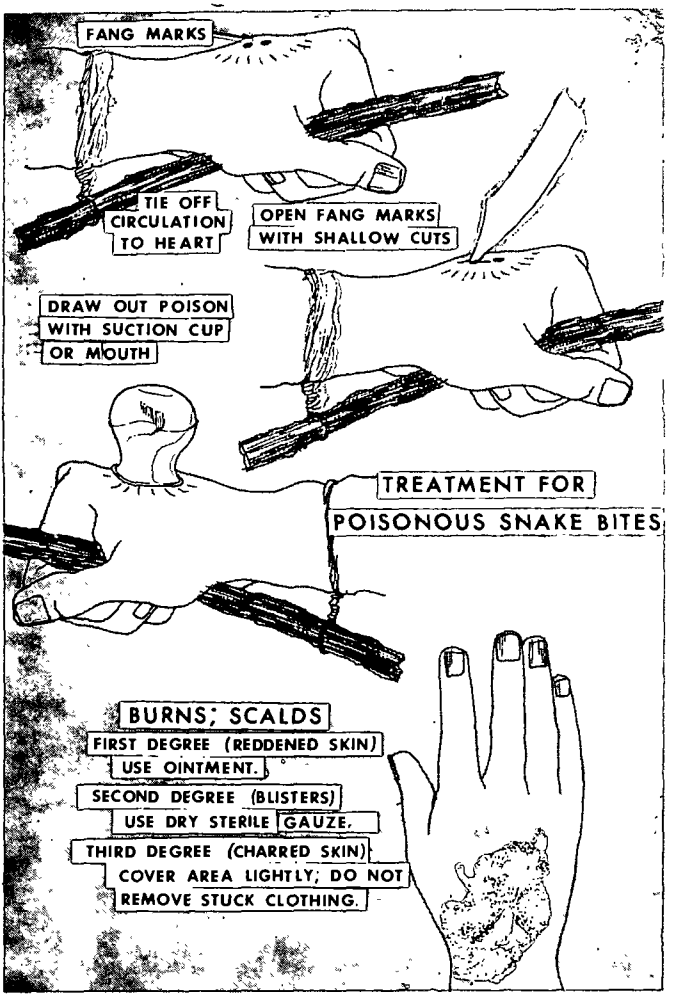
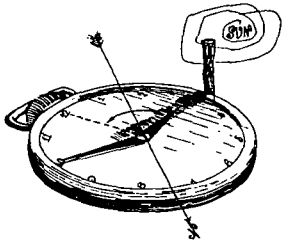


Figure 260—Continued.

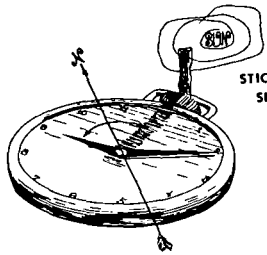
NORTH TEMPERATE ZONE

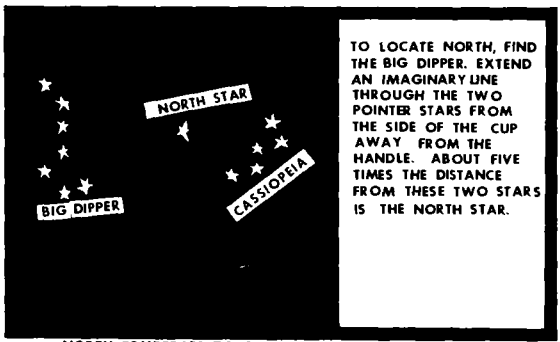


IN THE NORTH TEMPERATE ZONE POINT THE HOUR HAND TOWARD THE SUN. A NORTH-SOUTH LINE CAN BE FOUND MIDWAY BETWEEN THE HOUR HAND AND 12 O'CLOCK. TO DETERMINE WHICH END OF THE LINE IS NORTH, REMEMBER THAT THE SUN IS IN THE EASTERN SKY BEFORE NOON AND IN THE WESTERN PART IN THE AFTERNOON.

IN THE SOUTH TEMPERATE ZONE, POINT 12 O'CLOCK TOWARD SUN. HALFWAY BETWEEN 12 O'CLOCK AND THE HOUR HAND IS THE NORTH-SOUTH LINE. BEFORE NOON THE SUN WILL BE IN EASTERN SKY AND IN THE WESTERN SKY IN THE AFTERNOON.

SOUTH TEMPERATE ZONE





NORTH TEMPERATE ZONE

Figure 261. Guiding by sun and stars.

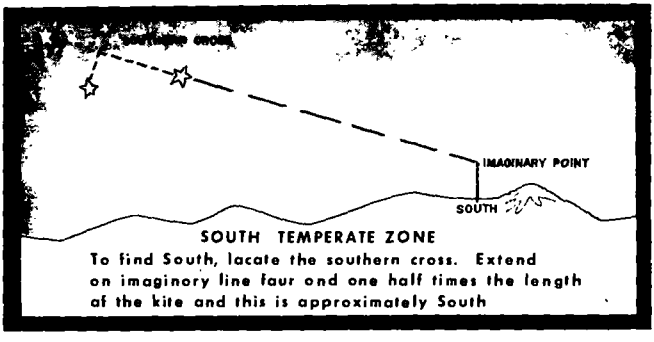


Figure 261—Continued.

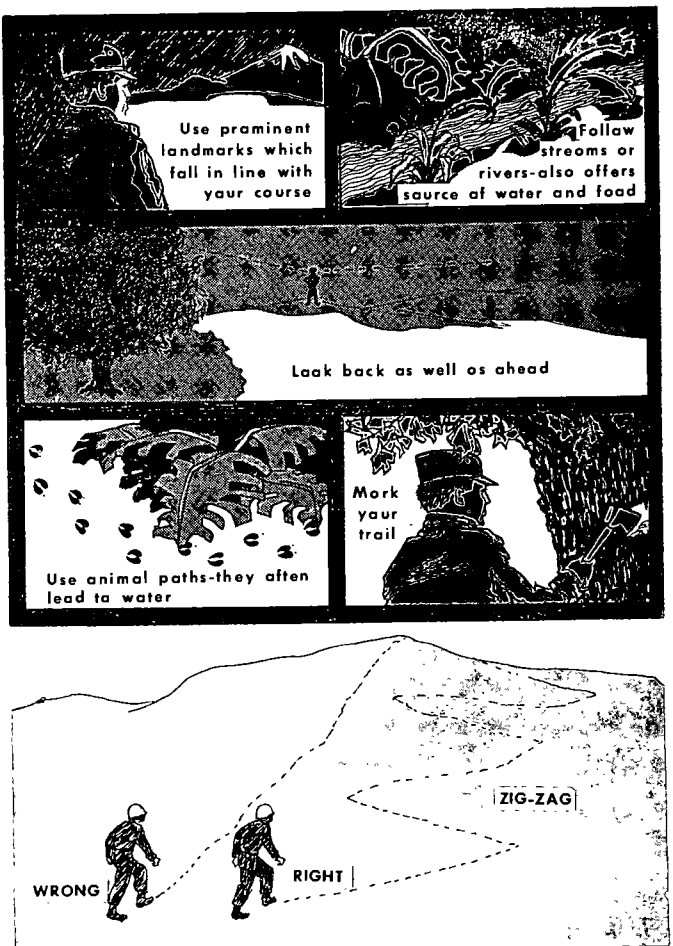


Figure 262. Keeping a course.

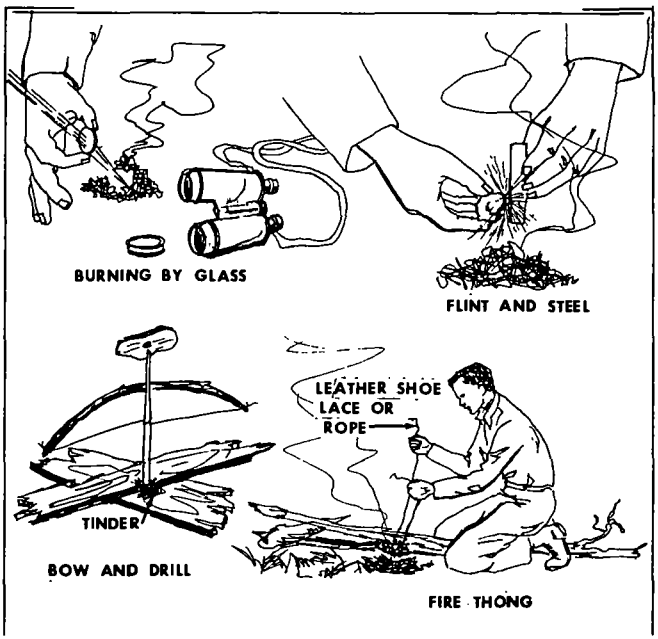


Figure 263. Firemaking.

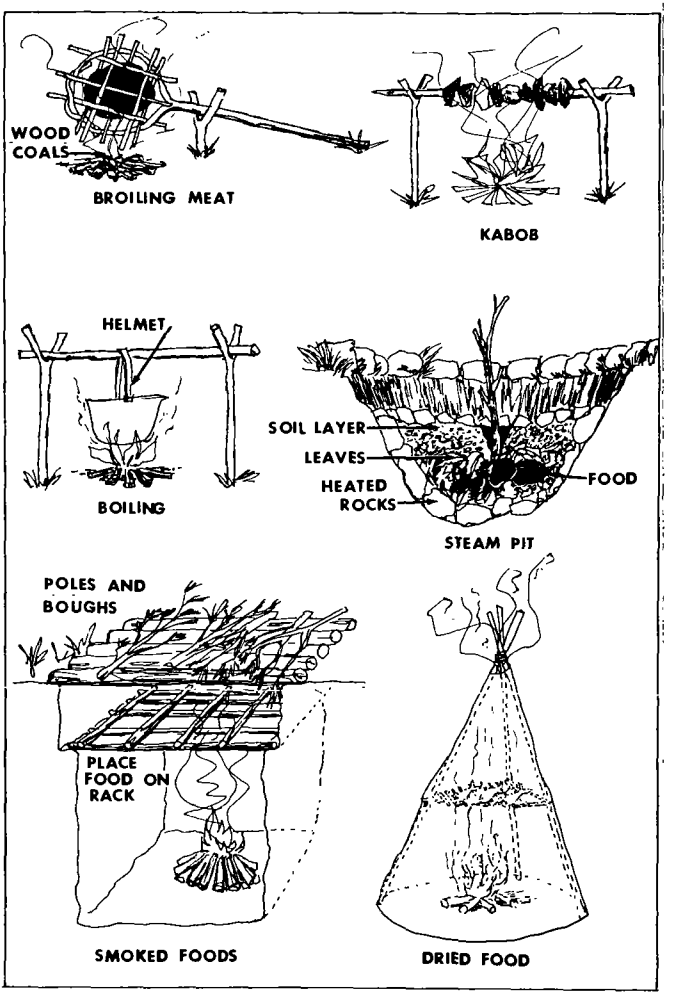


Figure 264. Cooking fires.

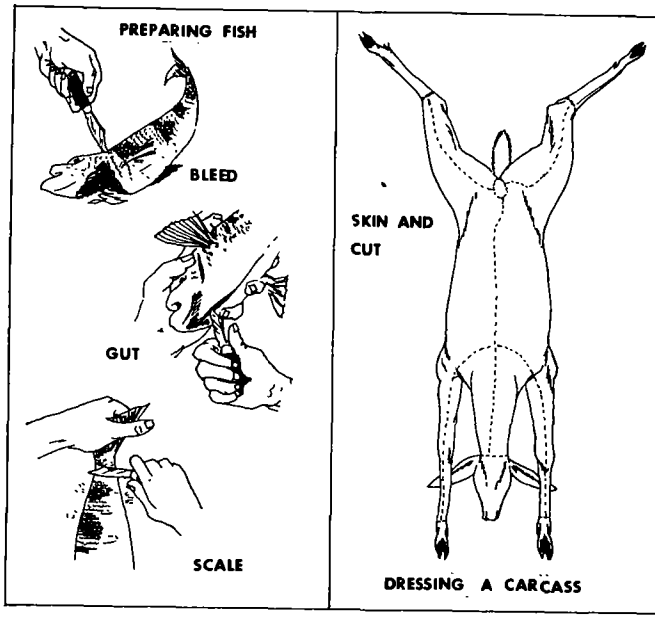


Figure 265. Preparing food.

CHAPTER 15

COMMUNICATIONS

109. Importance

Communication is one of the vital elements for success in combat. The purpose of this chapter is to acquaint you with the type of signal communications equipment most commonly found in an engineer unit.

110. Means of Communication

The most common means of communication are —messenger, wire, visual, and radio. An important point to remember is—there are no completely secure means of communication.

a. Wire Communication. Field wire communication systems are rugged, and, with the exception of the wire itself, can be installed and removed rapidly. A typical field wire communications system consists basically of field telephones, teletypewriters, and switchboards. Figures 266 through 268 illustrate different types of field telephones commonly used and their characteristics.

(1) *TA–43/PT.* The telephone set TA–43/PT is a rugged, lightweight, waterproof field telephone that may be used under

all outdoor conditions or as a desk or wall mounted telephone. It can be placed in service rapidly in any position or location required by the tactical situation.

(2) *TA–312/PT.* The telephone set TA–312/PT can be used as station equipment for local battery (LB) and com-

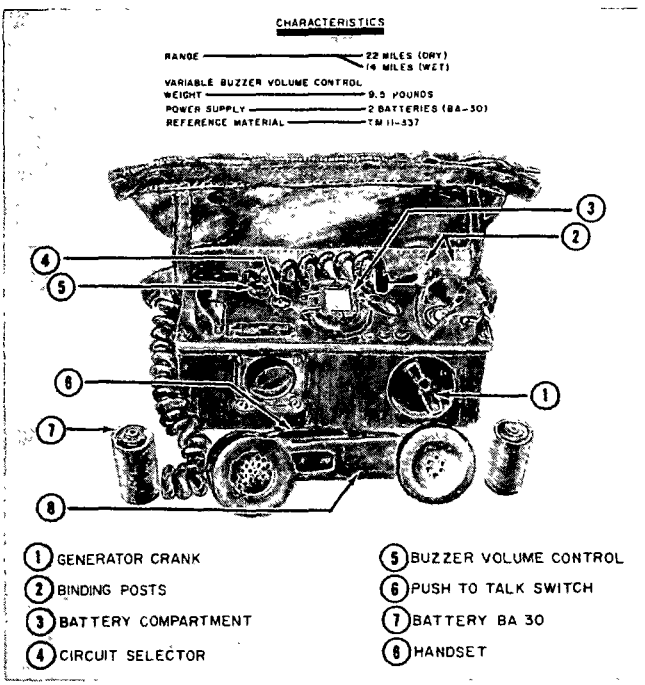


Figure 266. Telephone set TA–43/PT.

mon battery (CB) manual telephone systems. It can be used under all outdoor conditions, or as a desk or wall-mounted for indoor use. The press-to-talk switch on Handset H–60/PT can be used to control remotely operated equipment such as radio sets.

(3) *TA–1/PT.* The telephone set TA–1/PT is a sound-powered telephone intended for use on field wire lines in forward areas. It can be used for communica-

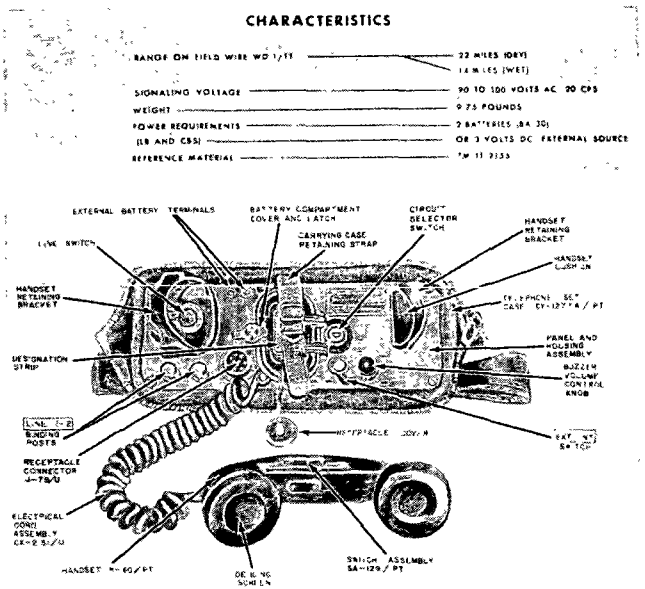


Figure 267. Telephone set TA–312/PT.

tions with any field telephone or local battery switchboard.

b. Visual Communication. The visual communications systems used today consist of flags

CHARACTERISTICS

RANGE ON FIELD WIRE WD-1/TT	3 TO 5 MILES
SIGNALING RANGE ON WO-1/TT	3 TO 5 MILES
SIGNALING VOLTAGE	65 TO 80 VOLTS AC
TEMPERATURE LIMITS FOR OPERATION	-40 TO + 130° FAHR
REFERENCE	TM-11-2153

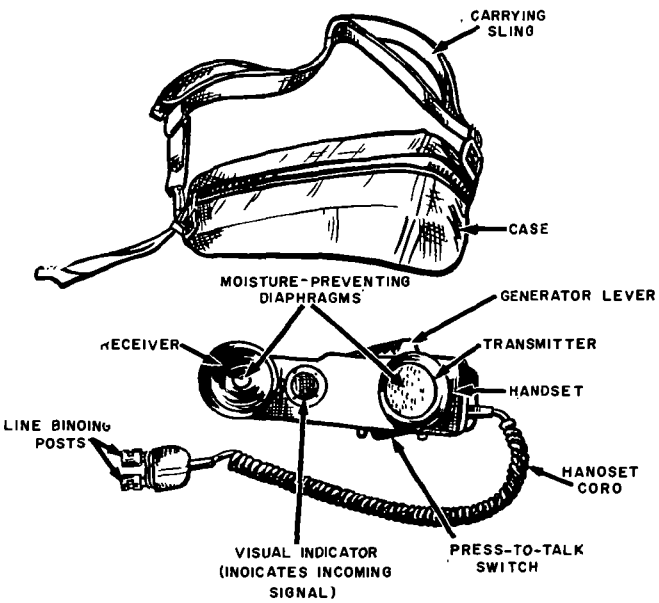
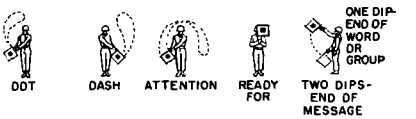


Figure 268. Telephone set TA-1/PT.

(wig-wag and semaphore), standard arm and hand signals, ground-air emergency code, panel markers, lights, pyrotechnics and infrared devices. Visual signals are very vulnerable to interception, and the enemy may use similar signals for purposes of deception and confusion. The use of visual signals is restricted during periods of poor visibility, or when line-of-sight locations are not available. Use of visual signals may be prohibited for security reasons. Illustrations of the various methods of visual communications are shown in figures 269 through 271. Standard arm and hand signals used in the control of units in tactical situations are covered in FM 21–6.



WIG-WAG (MORSE CODE)

A ·—	J ·–––	S ···	2 ··––––
B –···	K –·–	T –	3 ···––
C –·–·	L ·–··	U ··–	4 ····–
D –··	M ––	V ···–	5 ·····
E ·	N –·	W ·––	6 –····
F ··–·	O –––	X –··–	7 ––···
G ––·	P ·––·	Y –·––	8 –––··
H ····	Q ––·–	Z ––··	9 ––––·
I ··	R ·–·	1 ·————	0 —————

Figure 269. Wig-wag (Morse Code).

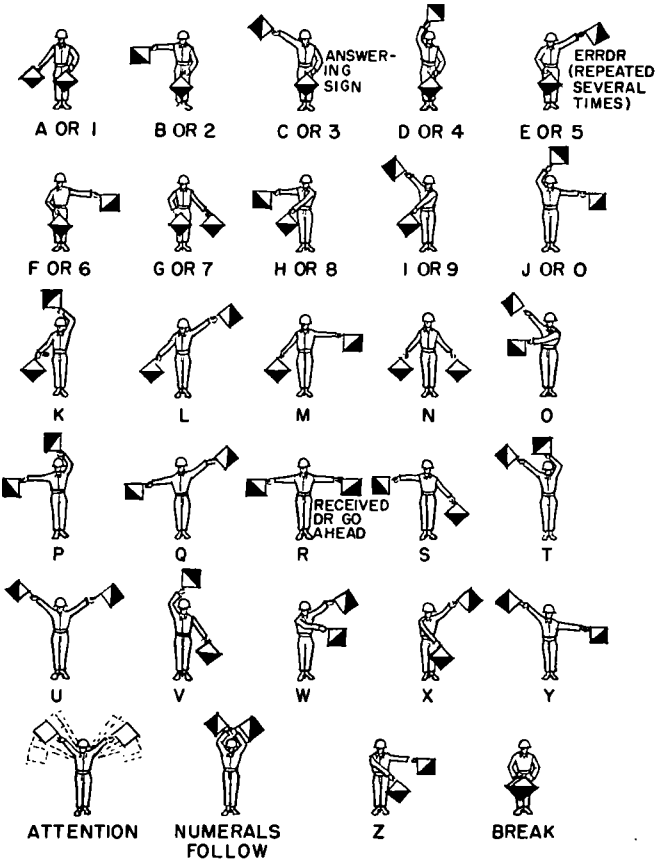


Figure 270. Semaphore.

c. Radio Communication. All commanders down to and including squad leaders are provided with radio communications equipment. Radios

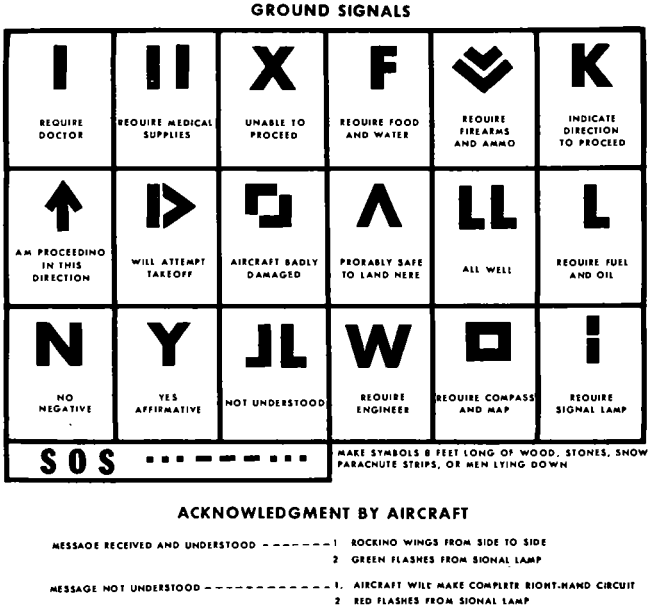


Figure 271. Emergency ground-air code.

are provided primarily for communication within the organization to which assigned and between operating elements of the organization which they are supporting. Before radios can be operated together, they must use the same frequency, modulation, and signal. Figures 272 through 273 illustrate the radio sets most commonly found in engineer units.

(1) *AN/PRC–25.* The radio AN/PRC–25 is a lightweight, transistorized, short

range, manpack VHF FM receiver-transmitter used for two-way communications in forward areas. The power source can be either a dry battery or a special vehicular power supply. The radio set can be operated in aircraft, in a vehicle, or while being carried by an operator. The AN/PRC–25 will net with any FM radio set in its frequency range.

(2) *AN/VRC–34.* Radio set AN/VRC–34, figure 273, will communicate with all AM radios having a corresponding frequency range and type of signal. It can be operated only as a vehicular radio set. The components required to operate this radio as a ground set were removed and made a part of radio set AN/GRC–87 (fig. 274) when the AN/GRC–9 radio set was repackaged. The AN/VRC–34 and AN/VRC–87 radio sets use the same receiver and transmitter but the former has only vehicular components while the latter has only ground components.

(3) *AN/VRC–18.* The radio set AN/VRC–18 (fig. 275) is an FM radio and will net with all FM radios having a corresponding frequency range. The radio set has an auxiliary receiver which can be used to monitor all transmissions within a frequency range from 38.0 to 55.0 mc.

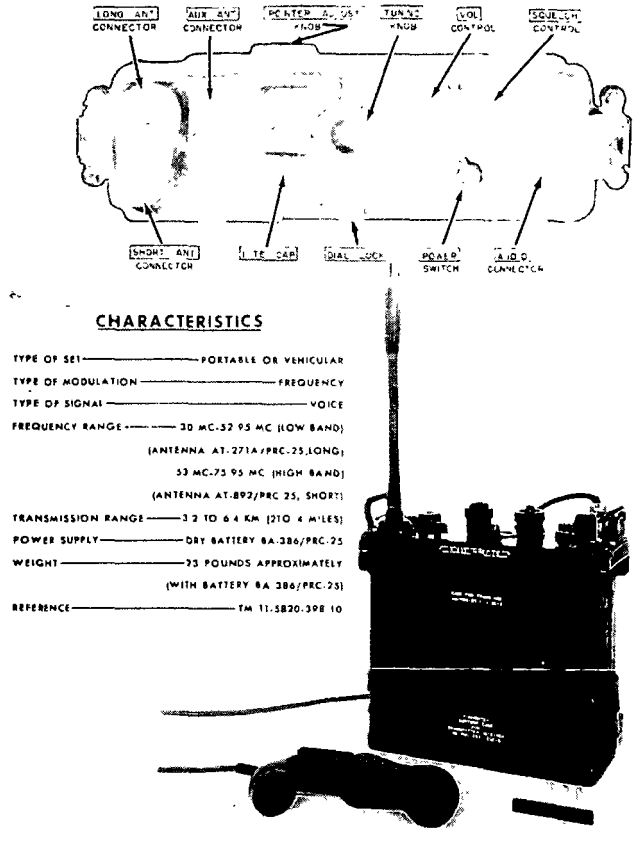


Figure 272. Radio set AN/PRC–25.

d. Vulnerability. Radio is less vulnerable to enemy fire than wire. However, it is subject to interference caused by static, enemy electronic

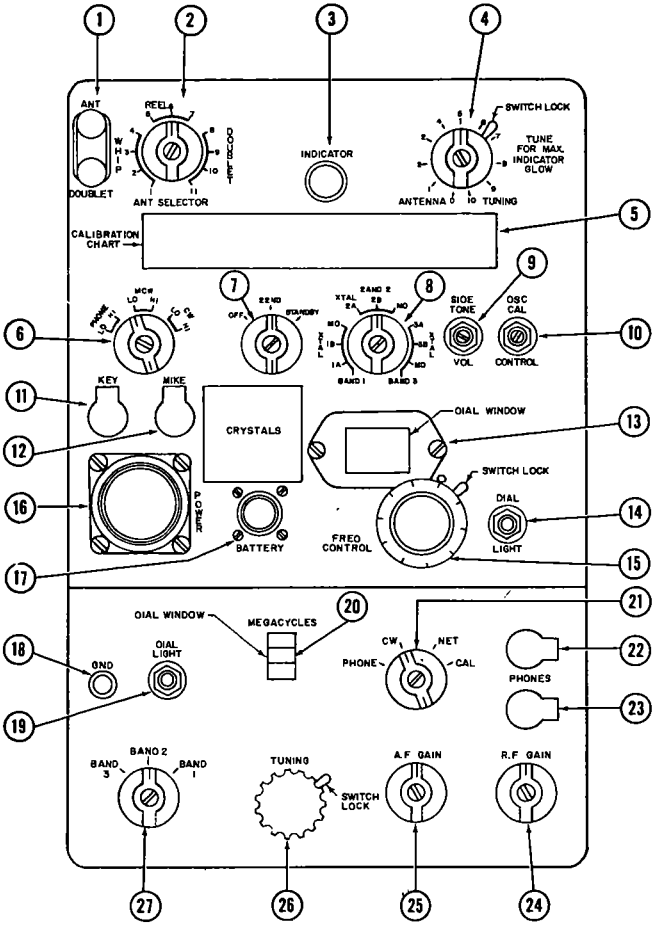


Figure 273. Radio set AN/VRC–34.

COMPONENTS OF AN/VRC-34 RADIO SET

1 ANTENNA DOUBLET
2 ANTENNA SELECTOR
3 INDICATOR
4 ANTENNA TUNING
5 CALIBRATION CHART
6 PHONE, MCW, CW SELECTOR
7 ON-OFF SWITCH
8 BAND SELECTOR
9 SIDE TONE ADJUSTMENT
10 OSCILLATION CALIBRATION
11 KEY JACK
12 MIKE JACK
13 DIAL WINDOW
14 DIAL LIGHT
15 FREQUENCY CONTROL
16 POWER INPUT
17 BATTERY JACK
18 GROUND
19 DIAL LIGHT
20 DIAL WINDOW
21 RECEPTION SELECTOR SWITCH
22 PHONE JACK
23 PHONE JACK
24 R.F. GAIN
25 A.F. GAIN
26 TUNING DIAL
27 BAND SELECTOR

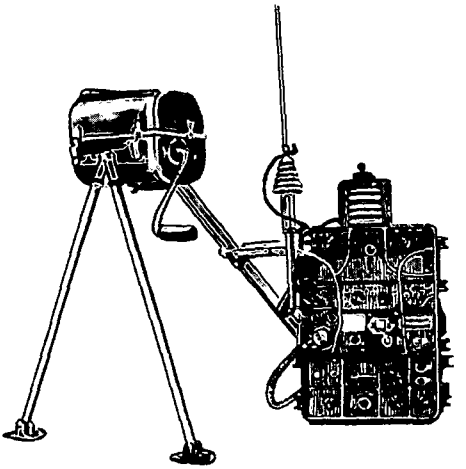
OPERATING INSTRUCTIONS FOR AN/VRC-34 AND AN/GRC-84 RADIO SETS

1. TO TURN ON RADIO SET
   a. Turn switch (7) on transmitter to OFF.
   b. Turn on power supply.
   (BE SURE THAT THE KEY OR MIKE SWITCH IS NOT CLOSED)
2. TO RECEIVE
   a. Turn switch (7) on tronsmitter to SEND when communicating with another set. For reception only, turn switch (7) to STAND-BY.
   b. Turn switch (21) to the type of reception desired.
   c. Turn switch (27) to band position desired.
   d. Turn dial (26) to the frequency desired ond lock.
   e. Turn A. F. and R. F. GAIN controls (24 25) for a comfortable listening level in the headset.
3. TO TRANSMIT
   a. Turn switch (6) to type tronsmission desired.
   b. Turn switch (2) to the highest ontenna position used.
   c. Turn switch (8) to the band position desired.
   d. Turn switch (21) to the diol setting corresponding to the frequency given on the colibrotion chort and lock.
   e. See that the red dots on INDICATOR (3) lenses ore adjacent to each other.
   f. For phone operation, switch (6), woit 2 seconds ofter closing the mike switch before speaking. Speak in a loud clear voice.
4. TO TURN RADIO SET OFF
   a. Turn switch (7) to OFF.
   b. Turn the power switches OFF.

Figure 273—Continued.

CHARACTERISTICS

TYPE OF SET——GENERAL GROUND USE
TYPE OF SIGNAL——VOICE,CW,MCW
TYPE OF MODULATION——AM
FREQUENCY RANGE (CONTINUOUS TUNING)——2.0 TO 12.0 MC



TRANSMISSION RANGE:

TYPE SIGNAL	STATIONARY	MOVING
CONTINUOUS WAVE	30 MILES	20 MILES
VOICE	15 MILES	10 MILES

POWER SUPPLY——BA-317/U and G-43/U
WEIGHT——135 POUNDS APPROX.
REFERENCE——TM 11-263

Figure 274. Radio set AN/GRC–87.

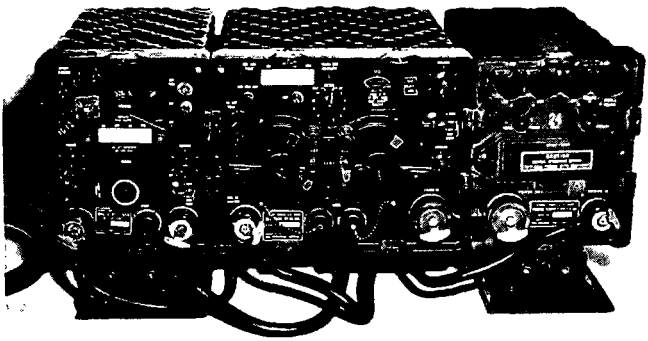


Figure 275. Radio set AN/VRC–18.

jamming devices, and other radio stations operating on the same frequency.

e. Radio Security. Radio is the least secure means of communication. It is always assumed that interception takes place every time a message is transmitted by radio. For this reason, radio communication security is a constant consideration. The enemy obtains information merely by knowing that radios are operating and this may make it necessary to restrict or prohibit their use for periods of time.

f. Phonetic Alphabet. The phonetic alphabet, shown below, is used in voice communication with radio or wire whenever there is a possiblity that the word or letter may be misunderstood during the transmission.

A—Alfa
B—Bravo
C—Charlie
D—Delta
E—Echo
F—Foxtrot
G—Golf
H—Hotel
I—India
J—Juliet
K—Kilo
L—Lima
M—Mike
N—November
O—Oscar
P—Papa
Q—Quebec
R—Romeo
S—Sierra
T—Tango
U—Uniform
V—Victor
W—Whiskey
X—X-ray
Y—Yankee
Z—Zulu

0—Zero
1—Wun
2—Too
3—Thuh-ree
4—Fo-wer
5—Fi-yiv
6—Six
7—Seven
8—Ate
9—Niner

CHAPTER 16

THE ENGINEER—HIS TRANSPORTATION AND EQUIPMENT

Section I. CONSTRUCTION EQUIPMENT

111. Introduction

This chapter is included to familiarize the engineer soldier with the vehicles and equipment used in support of the engineer mission. All of these items will not necessarily be found in every engineer unit since the type and quantity are distributed on the basis of TOE authorizations. Some of these items have only recently been adopted as standard items and are not yet widely distributed, while others are still in the development stage.

112. Earthmoving

In construction work, there is often the requirement to move varying quantities of earth over short, medium, and long distances. To fulfill this requirement, the Corps of Engineers uses several types of earthmoving equipment. A few of the common pieces of this type are shown in figures 276 through 278.

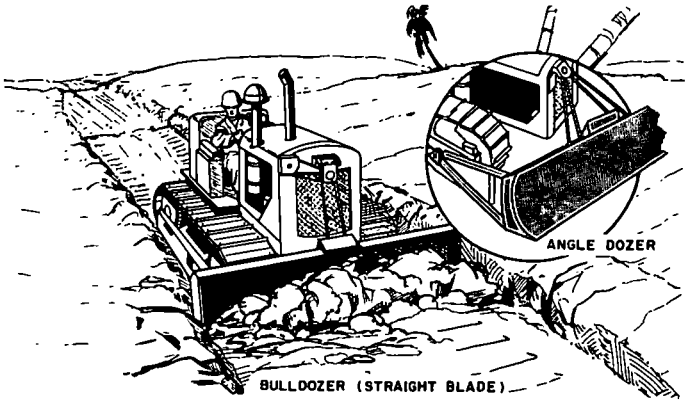


Figure 276. Crawler tractor with dozer blade.

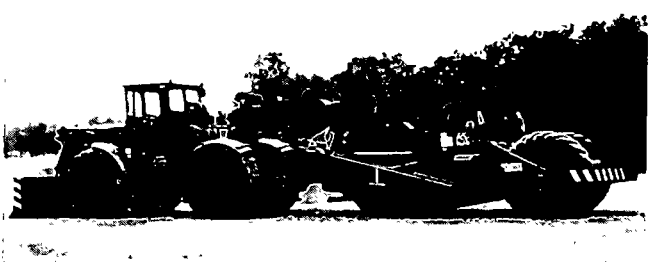


Figure 277. Eighteen-yard scraper with prime mover.

113. Compaction

The development of strong soil foundations (base courses) for roads, airfields, and associated projects requires the use of special compaction equipment to keep pace with the earthmoving

equipment. A typical piece of compaction equipment, sheepsfoot roller, is shown in figure 279.

114. Concrete

Many Corps of Engineers projects involve concrete operations. The Corps of Engineers uses a variety of equipment in concrete operations; however, the most common piece of equipment is the 16–S concrete mixer (fig. 280).

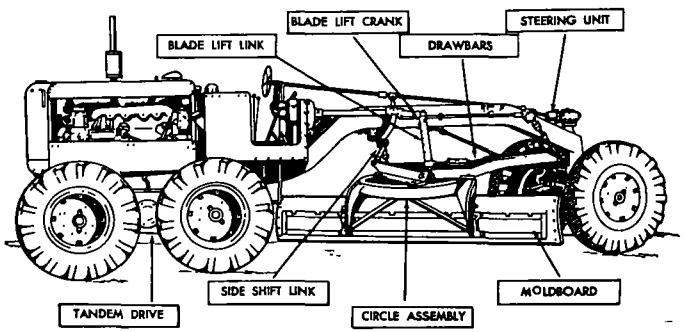


Figure 278. Motorized grader.

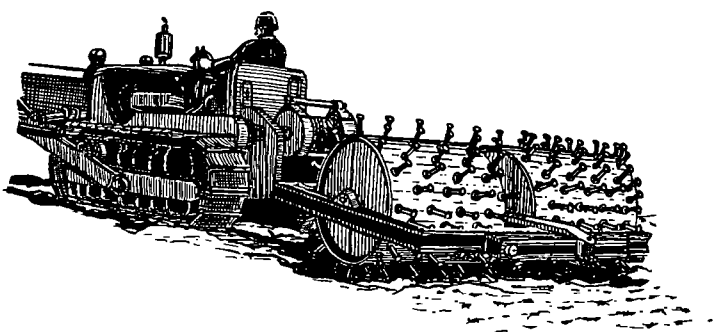


Figure 279. Sheepsfoot roller.

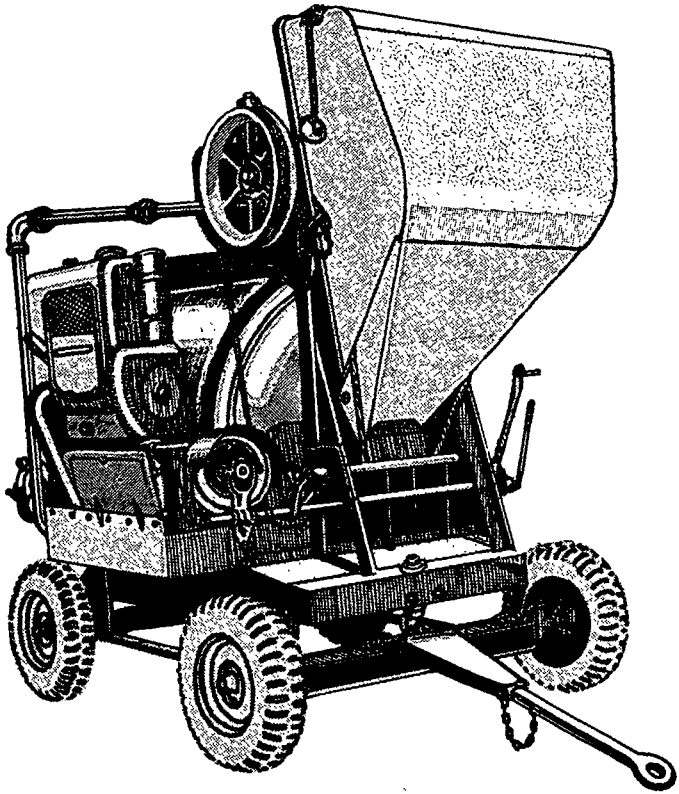


Figure 280. Concrete mixer, 16-cubic feet.

115. Lifting and Loading

Due to the size and weight of construction materials, the engineers require highly mobile lifting and loading equipment in support of the mission. Figures 281 through 284 illustrate the most common lifting and loading equipment available.

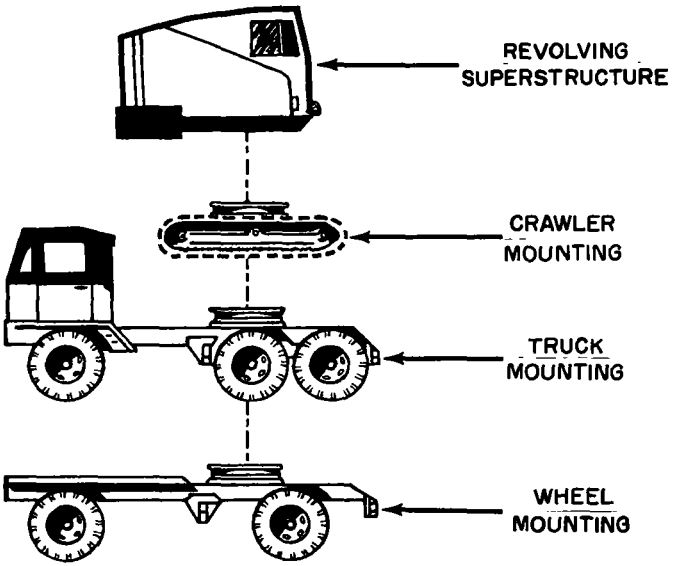


Figure 281. Types of crane mountings.

116. Special

Engineer troops are often committed on special type operations. To support these, special equipment has been designed and made available. It would be impractical to list all of these in this manual; however, figures 285 through 287 illustrate some of the more common types of special engineer equipment.

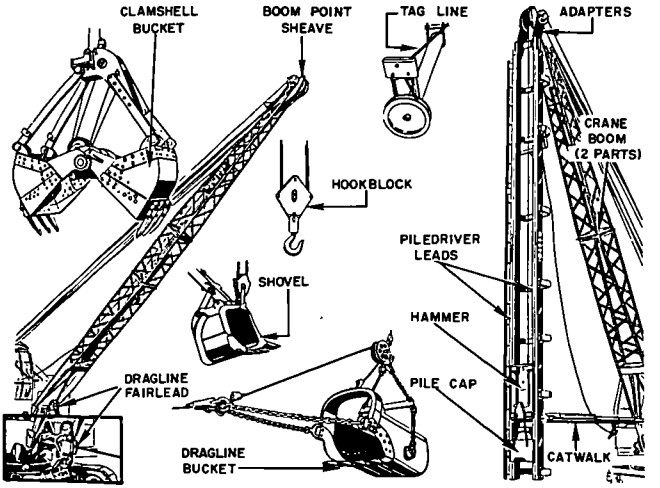


Figure 282. Crane-shovel attachments.

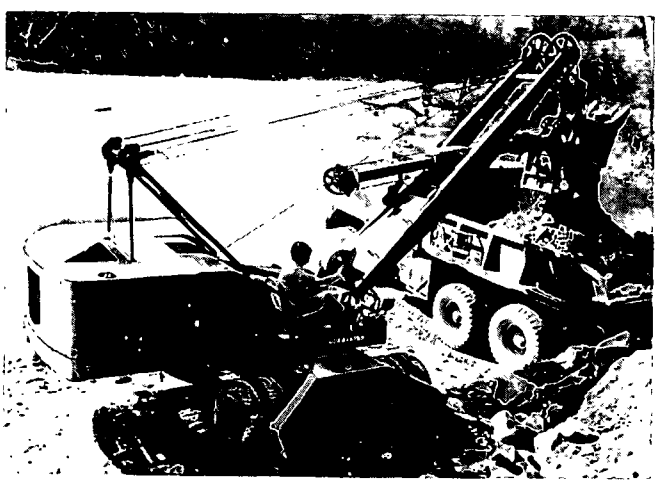


Figure 283. Crane.

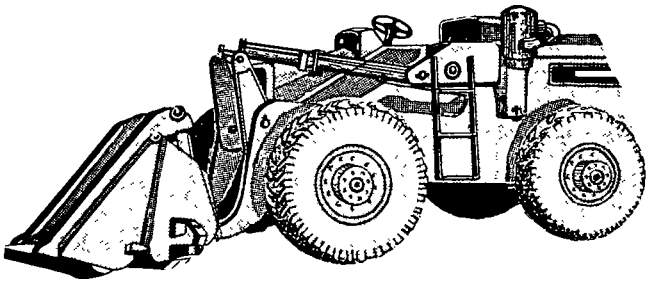


Figure 284. Scoop loader.

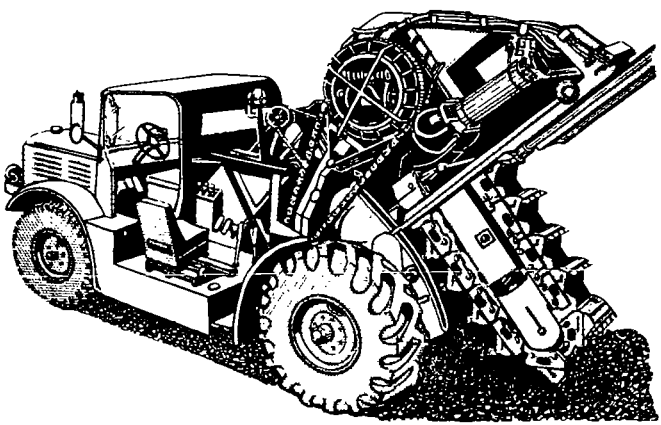


Figure 285. High speed intrenching machine.

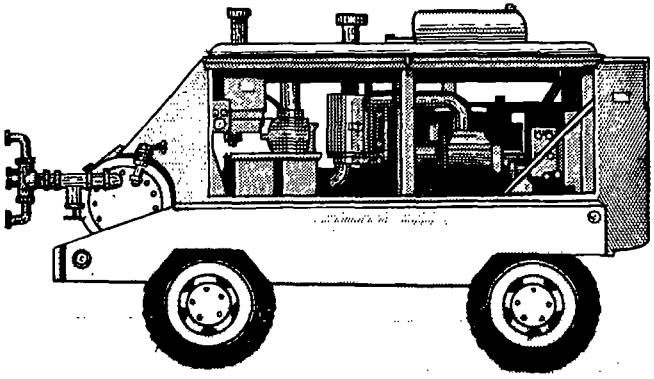


Figure 286. 600 cubic foot/minute air compressor.

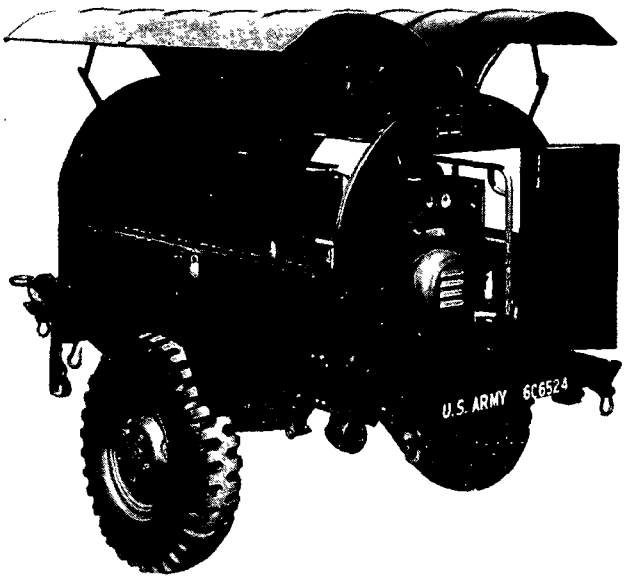


Figure 287. Portable electrical pioneer tool set.

117. Types of Vehicles

The following vehicles (figs. 288 through 294) are those most commonly used in engineer units to meet administrative and combat support transportation requirements.

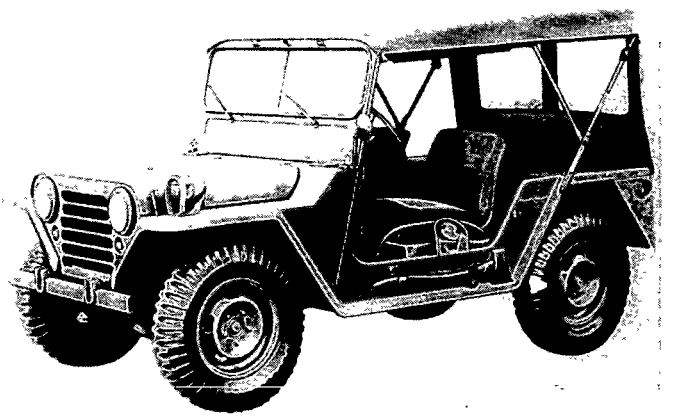


Figure 288. One-quarter-ton truck ("jeep").

118. Expedient Vehicle Recovery Operations

The possibility of transportation becoming disabled due to the effects of weather and terrain, enemy action, or mechanical malfunction should never be discounted. When this happens, you may find that assistance from qualified and experienced recovery teams using organic recovery

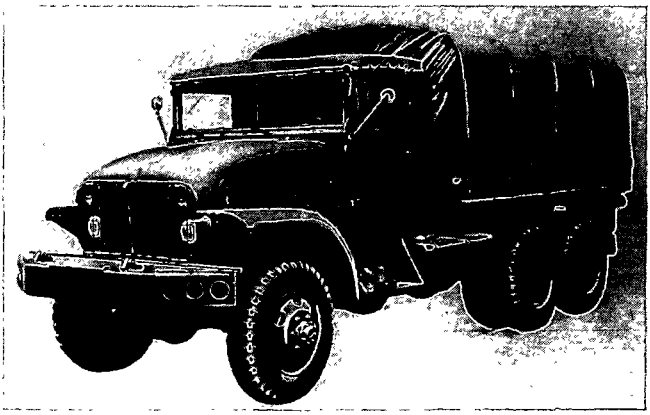


Figure 289. Two and one-half-ton cargo truck.

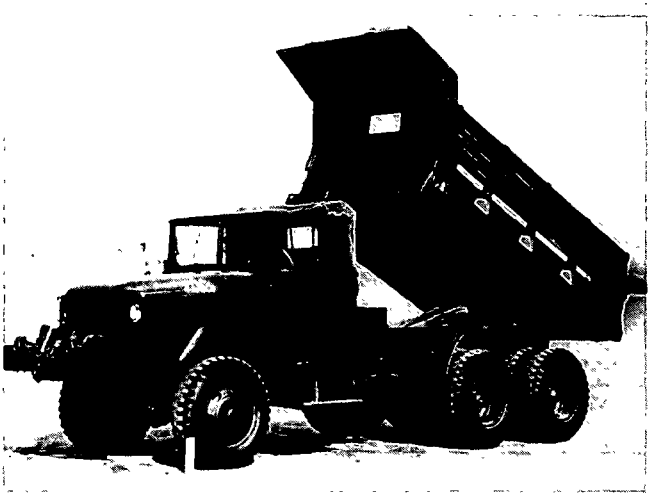


Figure 290. Two and one-half-ton dump truck.

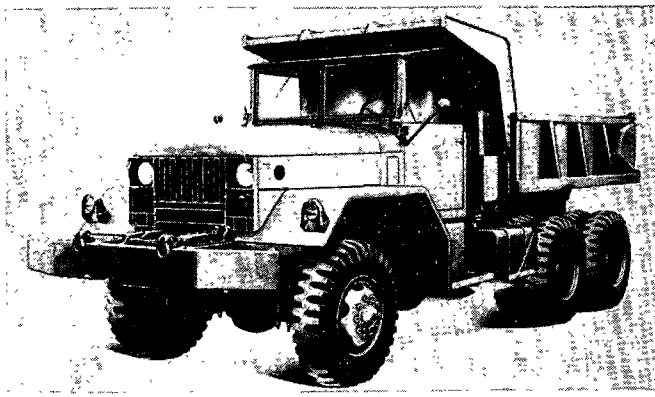
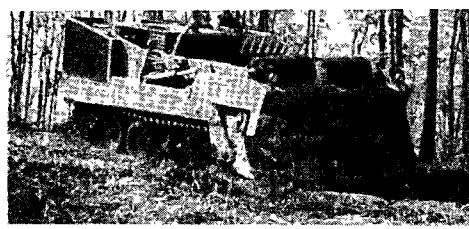


Figure 291. Five-ton dump truck.



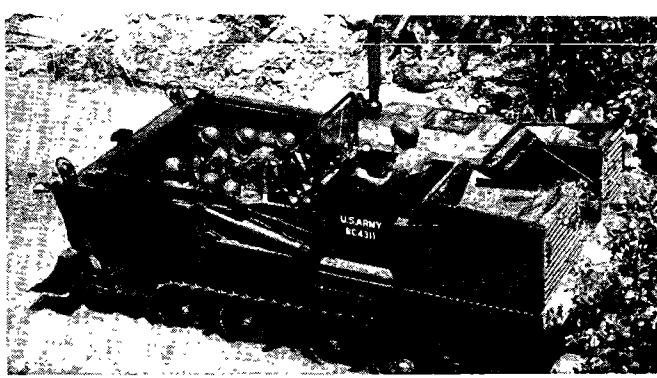


Figure 292. Universal engineer tractor (UET).

Figure 293. Combat engineer vehicle (CEV).

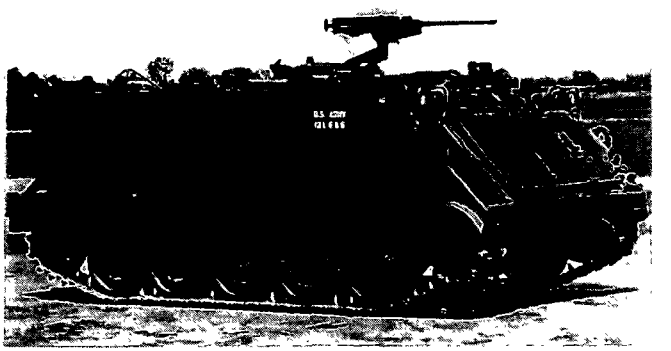


Figure 294. Armored personnel carrier (APC).

vehicles and equipment are not available. The engineer soldier should then apply the training and experience he has gained in rigging in order to aid in recovering the vehicle. Figures 295 through 301 illustrate expedient vehicle recovery techniques based on elementary rigging principles. Use them when necessary.

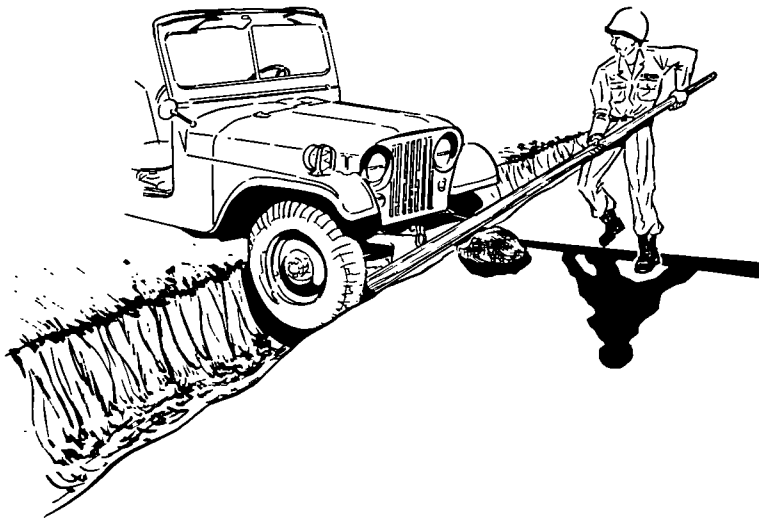


Figure 295. Simple lever.

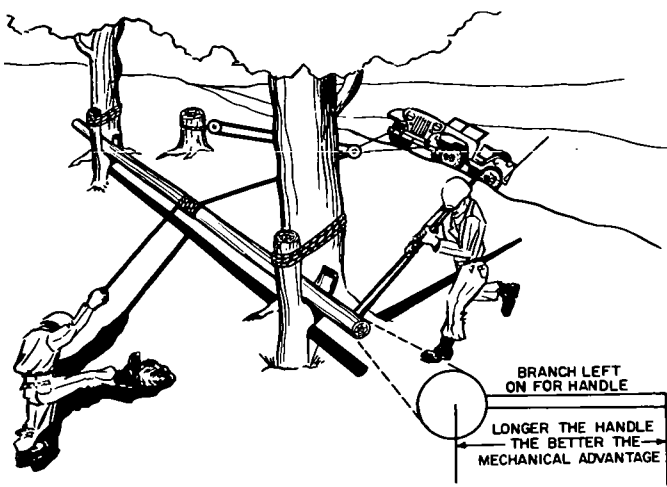


Figure 296. Windlass.

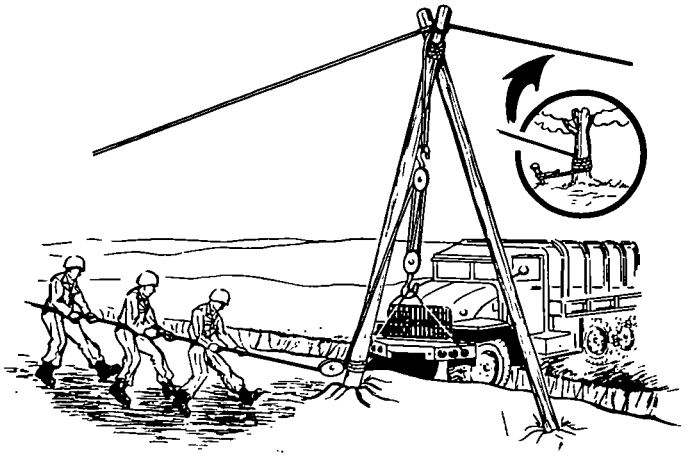


Figure 297. Use of an A-frame.

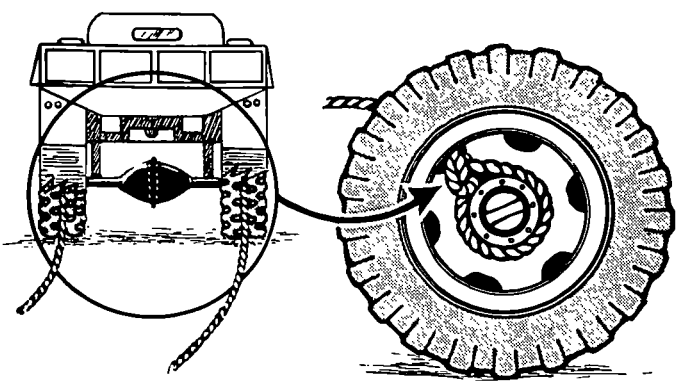


Figure 298. Use of wheels for a winch.

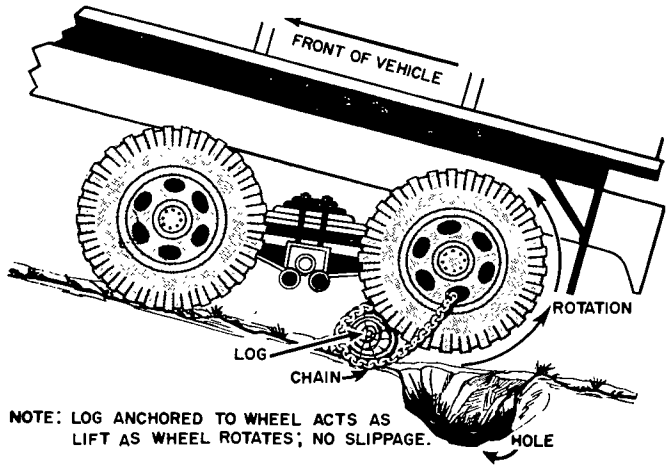


Figure 299. Anchoring a wheel.

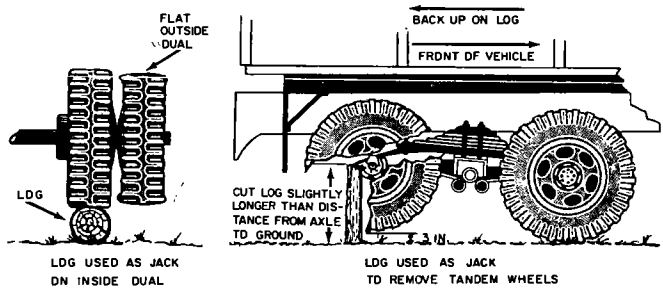
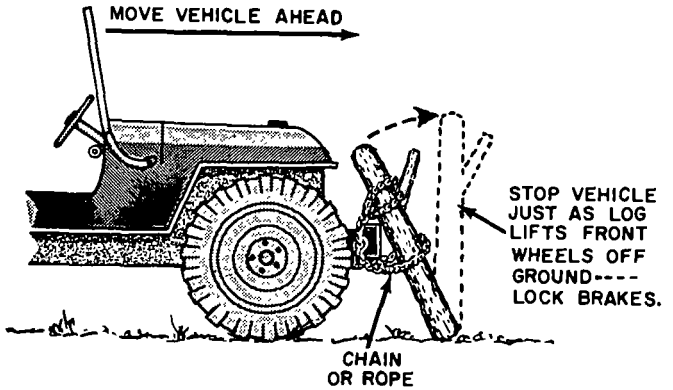


Figure 300. Substitutes for a jack.



LOG LASHED TO BUMPER TO REMOVE FRONT WHEELS.

Figure 300—Continued.

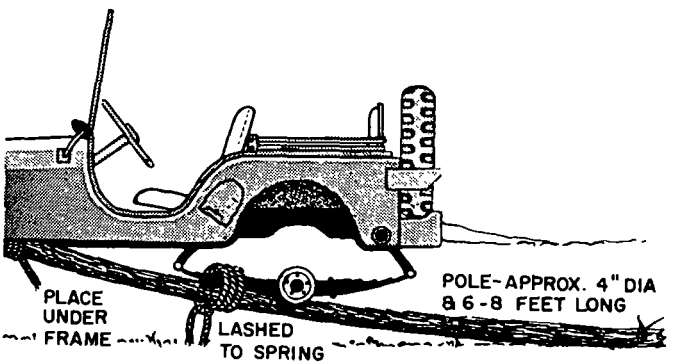


Figure 301. The skid.

CHAPTER 17

WEAPONS COMMON TO THE ENGINEER

119. Basic Considerations

One of the principal elements of engineer doctrine is that the engineer soldier must be trained to protect himself, his worksite, and reinforce the infantry when necessary. Therefore, you as an engineer soldier, should be thoroughly qualified with your assigned weapon; know its capabilities and limitations; and maintain it properly to assure efficient operation at a moment's notice. On your assignment to an engineer unit you will be cross-trained in the care and cleaning, and familiarization firing of other types of weapons organic to the unit. This chapter lists those weapons common to the engineer which will assist in carrying out the responsibilities in this area.

120. Types and Characteristics

The principal weapons used by engineers and their characteristics are shown in table IV.

Table IV. Characteristics

Weapon	Weight (lbs)	Type of feed	Method of operation	Cyclic (C) or maximum rate (m) of fire (RDS per min)
U. S. Carbine cal .30, M2	5.5	30 rd mag	Gas operated semiauto and auto	750–775(C)
U. S. Rifle cal .30, M1	9.5	8 rd clip	Gas operated semiauto	N/A
U. S. Rifle 7.62 mm, M14	9.7	20 rd mag	Gas operated semiauto and auto	700–760(C)

Sustained rate of fire (RDS per min)	Maximum effective rate of fire (RDS per min)	Maximum range (Nearest 25 meters)	Maximum effective range (meters)	Remarks
40–60	40–60	2025	250	To be replaced by M14 rifle. May be equipped with sniper-scope infrared set No. 1, 20,000 volts.
8–10	16–24	3200	460	To be replaced by M14 rifle. May be equipped with grenade launcher M743.
15-semi-auto 20-auto	20–40 semiauto 40–60 auto	3200	460	Full auto capability requires installation of selector. Sustained rate based on limited tests. Bi-pod is a major item and used in conjunction with rifle when used as an auto rifle.

Weapon	Weight (lbs)	Type of feed	Method of operation	Cyclic (C) or maximum rate (m) of fire (RDS per min)
Machinegun 7.62 mm, M60	23	Belt metallic link	Gas operated auto	550(C)
Pistol .45 cal	3	7 rd mag	Recoil operated semiauto	N/A
40 mm grenade launcher, M79	6.25	N/A	Percussion type single shot	N/A
3.5 inch rocket launcher M20A1B1	13 (unloaded) 21 (loaded)	manual	N/A	12–18

Sustained rate of fire (RDS per min)	Maximum effective rate of fire (RDS per min)	Maximum range (Nearest 25 meters)	Maximum effective range (meters)	Remarks
100	200	3200	1100	Max. effective range limited by gunner's ability to see and adjust on target.
N/A	N/A	1500	50	None.
N/A	N/A	400	400	Min. safe range: combat; 31 meters training; 50 meters.
4	4	825	Armor: 185-moving 275-stationary Other: 275	Effective range based on skill of average gunner and armor defeating ranges against L-light, M-medium, H-heavy tanks.

CHAPTER 18

FUNDAMENTALS OF LAND MINE WARFARE

121. Introduction

The threat of nuclear weapons in modern warfare dictates the wide dispersion of units and results in expanded gaps between them. The high battlefield mobility possessed by the armies of the world demands effective means for stopping or slowing enemy land movement. Land mine warfare acts as a deterrent to enemy mobility and assists in denying enemy penetration between dispersed units. All troops must be capable of applying land mine warfare against hostile forces and to counteract the land mine warfare devices employed by an enemy.

122. Definitions

a. A mine is a contained explosive or other material designed to destroy or damage vehicles, ships, aircraft, or to kill, wound, or otherwise incapacitate troops. It may be detonated by the action of its victim, by the passage of time, or by controlled means.

b. A minefield is an area in which a quantity of mines are laid.

123. Uses

Mines assist in providing all-round protection and security both in the combat zone and rear areas. They are also effective against waterborne or airborne attack. The employment of land mines is not limited to an overall barrier plan. Small units can effectively use them whether they are occupying isolated defensive positions or during temporary halts when maximum security is desired. In guerrilla infested regions, mines help protect positions, areas, and installations from infiltrations and penetrations. In the hands of friendly partisan and special forces, they are used to disrupt enemy routes of communication. Mines may be used as boobytraps (FM 5–31) and as expedient demolitions (FM 5–25). For a detailed reference to land mine warfare, refer to FM 20–32.

124. Types of Mines

Land mines, which are shown in figure 302, are of two general types—*antipersonnel* and *antitank* mines.

125. Mine Cluster

A cluster may consist of one mine or as many as five mines of certain types as shown in figure 303. When more than one mine is used, the additional mines are placed within a 2-pace radius semicircle of the base mine. Only one AT mine is placed in a cluster and it is the *base* mine. An antipersonnel mine, preferably metallic, becomes

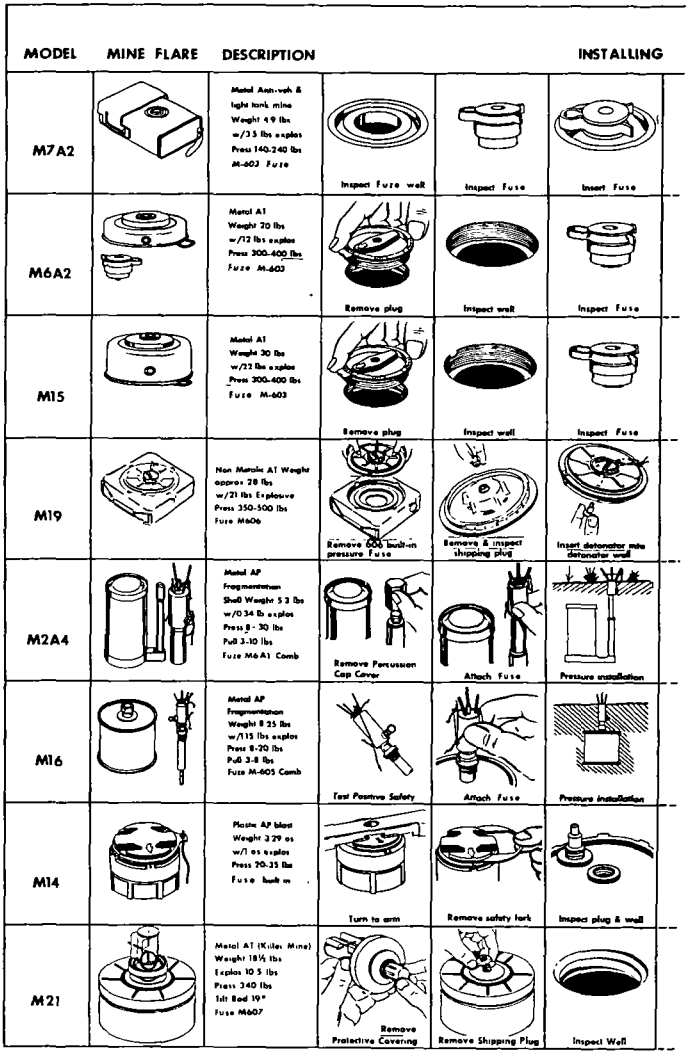


Figure 302. Types, installation, and arming of land mines.

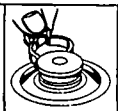
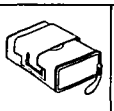
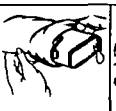
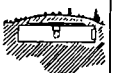
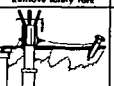
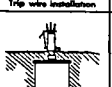
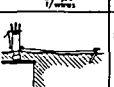
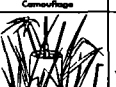
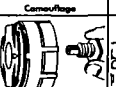
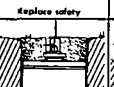
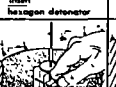
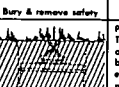
AND ARMING				REMARKS
 Remove safety	 Replace plate	 Sandbag cover	Bury	Cover needed to prevent dirt from getting between plate & mine T Boobytrapping well is in the end of mine Camouflage Normally buried flush with ground surface
Remove safety	Insert Fuze	Replace plug in safe position	Turn dial to arm	2 Boobytrapping wells Bury with top pressure plate even w/or slightly above ground level Camouflage Supplemental 8 lbs charge 2" thick may be fitted to M-6
Remove safety	Insert Fuze	Replace plug in safe position	Turn dial to arm	2 Boobytrapping wells Bury with top pressure plate even w/or slightly above ground level Camouflage Disables any tank known
Bury	Remove safety fork	Turn to arm	 Camouflage	2 Boobytrapping wells Disables any tank known Bury with top pressure plate even w/or slightly above ground level Camouflage
Trip wire installation	 Installing T/wires	Camouflage	Remove safeties	Cas rad - 10 yds Shell explodes 6-8 ft in air Remove Locking Safety before removing Positive Safety
 Trip wire installation	 Installing T/wires	 Camouflage	Remove safeties	Cas Rad equal to M2A4 Explodes 2-4 ft in air Remove Positive Safety fast
Inspect detonator well	Replace safety	 Insert hexagon detonator	Bury & remove safety	Tie down mine using carrying cord Use issued M22 arming tool to turn pressure plate or unscrew shipping plug Pressure plate slightly above ground
Insert Fuze	 Bury	 Remove Safeties	 Replace Camouflage	Pressure or tilt rod operatron Type of terrain determines operation in pressure operatron bury with top pressure plate even with or slightly above ground level Soil must be firm and sides of excavation must be perpendicular for tilt rod operatron Disables any tank known

Figure 302—Continued.

the base mine when an AT mine is not used. If M23 chemical mines are used, they are usually installed in every eighth cluster of a row and are placed no closer than one in every fourth cluster of a row in the place of an antipersonnel mine. Clusters are spaced at 6-pace intervals between base mines in a row.

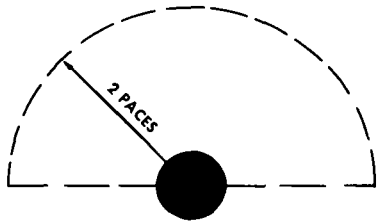
126. Mine Strip

A mine strip consists of two rows of mine clusters (fig. 304). The distance between rows is 6 paces. The minimum distance between adjacent strip centerlines is 18 paces. Strips need not be parallel with one another and may have as many turning points (changes of direction) as desired as long as the minimum distance of 18 paces between strip centerlines is maintained.

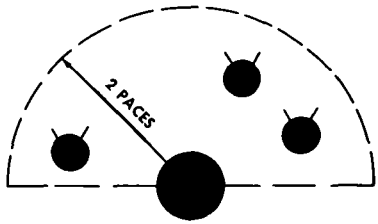
127. Fencing and Marking of Minefields

a. Rear Area Minefields. A rear area minefield must be completely fenced with two strands of barbed wire (fig. 305). The fence does not follow the exact boundary, but is erected so as to avoid indicating the exact boundary. It must not be placed less than 20 paces from the nearest mine. Standard marking signs (fig. 306) are hung on the upper strand so that the word "mines" faces away from the field. Minefields containing toxic chemical mines are marked in the same manner using the markers shown in figure 307. When toxic chemical mines are mixed with other type mines in the same minefield, both signs, "mines" and "gas" are hung close together.

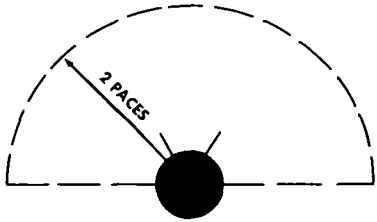
A CLUSTER MAY CONSIST OF ONE ANTITANK MINE



OR
ONE ANTITANK MINE PLUS SEVERAL ANTIPERSONNEL MINES WITHIN A 2-PACE SEMICIRCLE FROM THE ANTITANK MINE



OR
ONE ANTIPERSONNEL MINE



OR
SEVERAL ANTIPERSONNEL MINES FOUR OR LESS, WITHIN A 2-PACE SEMICIRCLE OF THE BASE ANTI PERSONNEL MINE

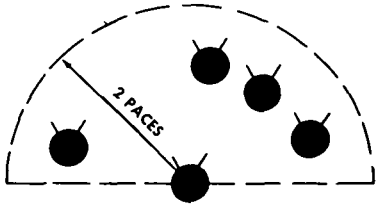


Figure 303. Mine cluster.

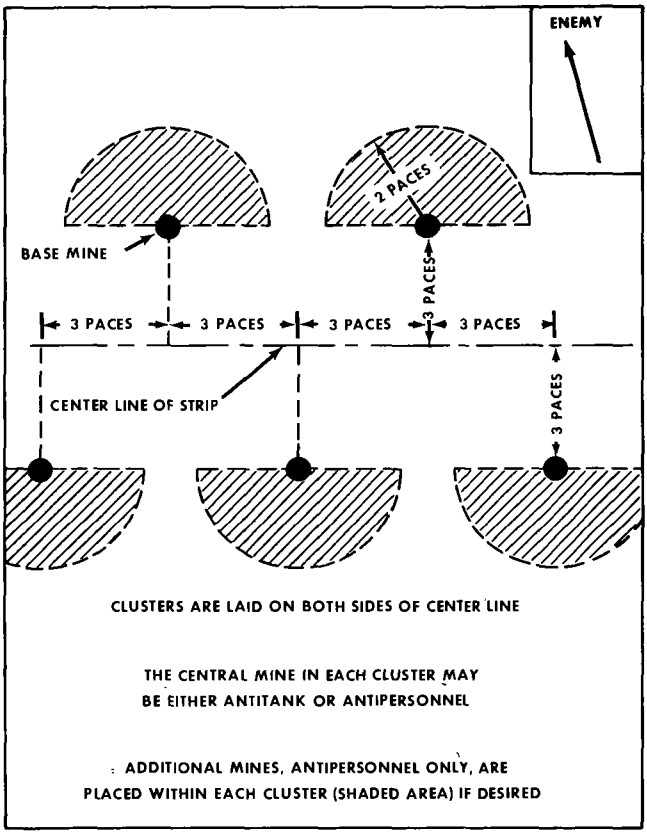


Figure 304. Mine strip.

b. Forward Area Minefields. Forward area minefields are marked as prescribed in *a* above, with the following exceptions:

(1) Minefields forward of positions along the Forward Edge Battle Area (FEBA)

are sometimes fenced only on the friendly (rear) sides or on the friendly sides and the flanks to protect friendly troops.

(2) Forward area minefields laid out of contact with the enemy may be completely fenced, but part of the fencing is removed before the enemy approaches them. On the other hand, there are times when higher headquarters may decide to leave the field completely inclosed to deflect or delay the enemy.

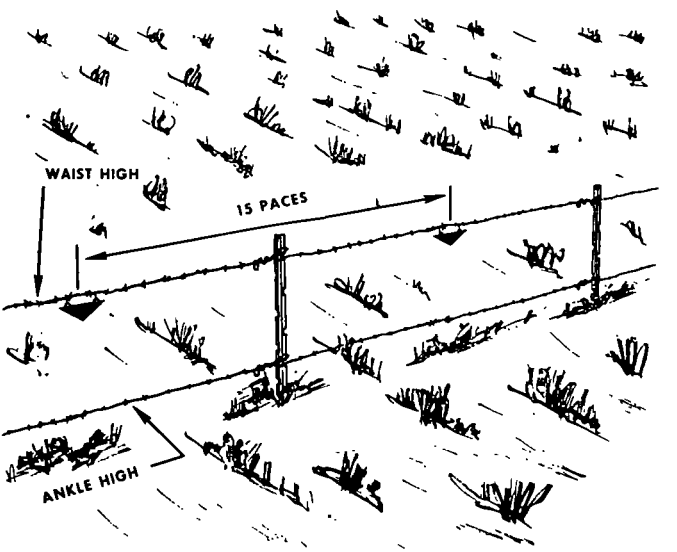


Figure 305. Minefield marking fence for minefields.

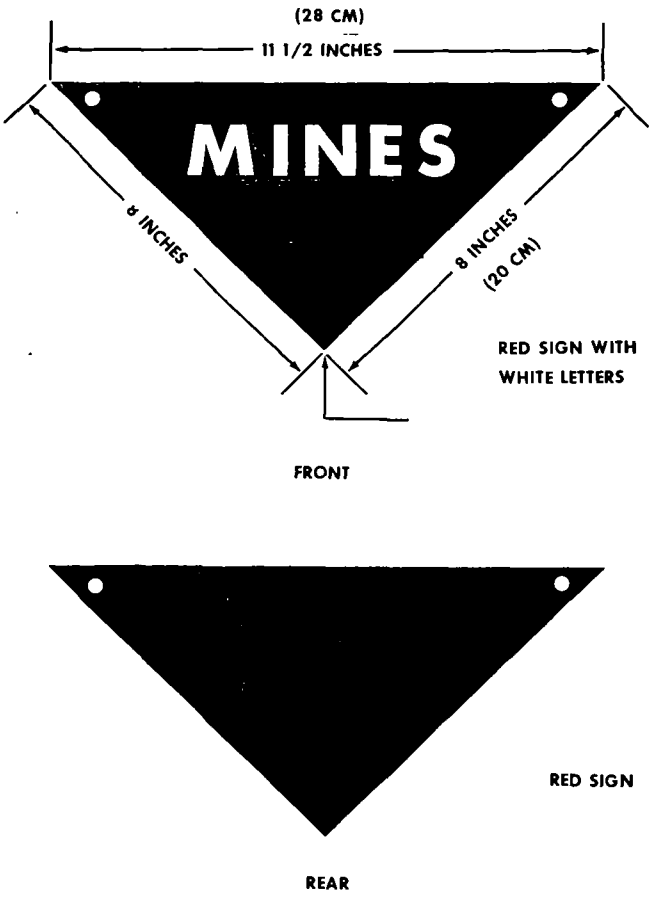
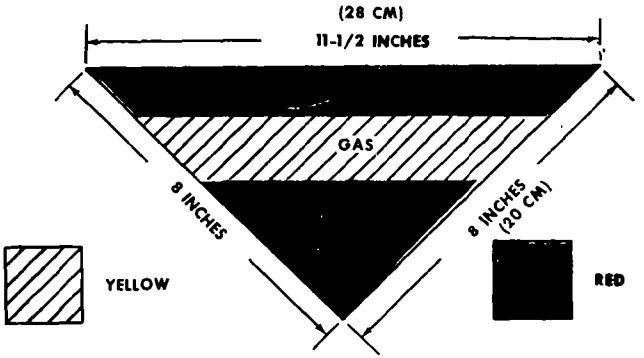
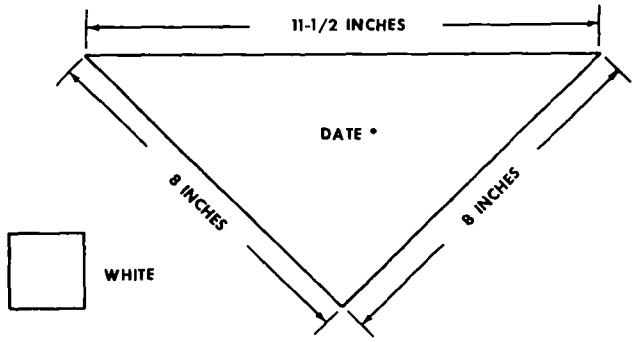


Figure 306. Standard minefield marking sign.



FRONT-SURFACE OF MARKER FACING AWAY FROM CONTAMINATION



BACK-SURFACE OF MARKER FACING CONTAMINATION

* DATE OF DISCOVERY OF CONTAMINATION AND AGENT (IF KNOWN) ENTERED ON MARKER AT TIME OF PLACEMENT

Figure 307. Standard toxic chemical mine sign.

APPENDIX I

REFERENCES

1. Department of the Army Pamphlets.

DA Pam 750–1	Preventive Maintenance Guide for Commanders

2. Field Manuals.

FM 5–1	Engineer Troop Organizations and Operations
FM 5–15	Field Fortifications
FM 5–25	Explosives and Demolitions
FM 5–34	Engineer Field Data
FM 5–35	Engineer's Reference and Logistical Data
FM 5–36	Route Reconnaissance and Classification
FM 5–135	Engineer Battalion, Armored Mechanized, and Infantry Divisions
FM 5–136	Engineer Battalion, Airborne Division
FM 5–142	Nondivisional Engineer Combat Units
FM 20–33	Ground Flame Warfare
FM 21–60	Visual Signals

FM 21–76 Survival
FM 23–90 81 mm Mortar, M29

3. Air Force Manuals.

AF Manual G4–3 Survival

4. Technical Manuals.

TM 5–210	Military Floating Bridge Equipment
TM 5–220	Passage of Obstacles Other Than Minefields
TM 5–270	Cableways and Tramways
TM 5–277	Panel Bridge, Bailey Type, M2
TM 5–312	Military Fixed Bridges
TM 5–331	Management; Utilization of Engineer Construction Equipment
TM 5–337	Bituminous, Concrete and Expedient Paving Operations
TM 5–460	Carpentry and Building Construction
TM 5–461	Engineer Handtools
TM 5–680	Electrical Facilities
TM 5–704	Construction Print Reading in the Field
TM 5–725	Rigging
TM 5–4003	Saw, Chain, Portable, Gasoline Driven
TM 11–263	Radio Set, AN/GRC–9 and AN/VRC–34
TM 11–337	Telephone Set TA–43/PT

TM 11–611	Radio Sets AN/VRC–16, AN/VRC–17 and AN/VRC–18
TM 11–2153	Telephone Set TA–1/PT
TM 11–2155	Telephone Set TA–312/PT
TM 11–5820–398–10	Radio Set AN/PRC–25

APPENDIX II

ENGINEER ORGANIZATIONS

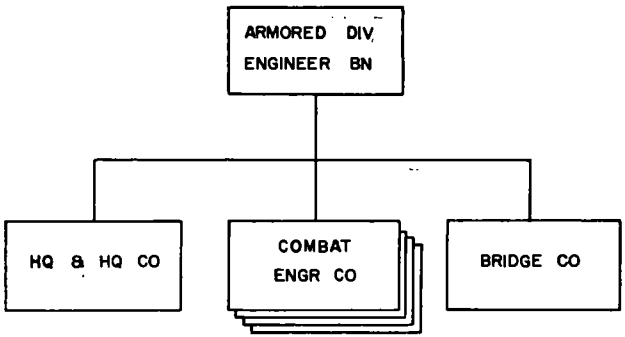
1. Combat Units

A study made by the U. S. Continental Army Command (USCONARC), known as the Reorganization Objectives Army Division (ROAD), developed a requirement for reorganizing the infantry, armored, and airborne divisions, and creating a mechanized division. The engineers employ *combat engineer battalions, divisional* to support these divisions. The engineer battalion, airborne division differs slightly from the armord, mechanized, and infantry engineer battalions by having one less combat engineer company and no bridge company. Figures 308 through 310 clearly indicate the differences mentioned.

2. Combat Support Units

The term combat support units is applied to combat engineer units which are not organic to combat divisions. These units are usually assigned to a corps or Army headquarters and are referred to as *nondivisional* units. These units are—

a. Engineer Brigade. The brigade is used when the control of a large-scale engineer operation



STRENGTH : OFF 45 WO 2 EM 939 AGG 989

MISSION : TO INCREASE THE COMBAT EFFECTIVENESS OF THE ARMORED DIVISION BY MEANS OF GENERAL ENGINEER WORK AND TO UNDERTAKE AND CARRY OUT ARMORED INFANTRY COMBAT MISSIONS WHEN REQUIRED.

Figure 308. Organizational chart, armored or mechanized division engineer battalion.

demands a single engineer command. The brigade is a flexible organization composed of two or more engineer combat groups.

b. Engineer Combat Group. The main mission of the engineer combat group is to perform large-scale engineer operations of a combat-support nature within a specified area or field of responsibility.

c. Engineer Combat Battalion, Army. The mission of the engineer combat battalion, Army, is to increase the combat effectiveness of a corps

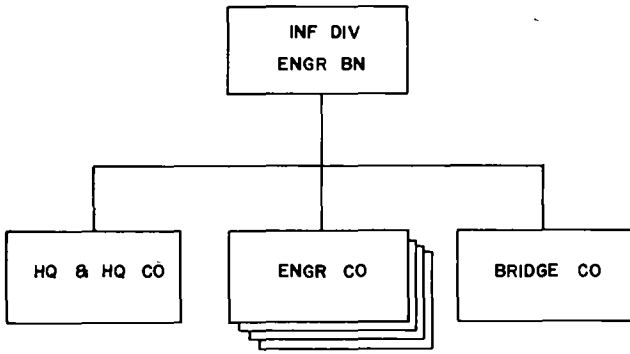
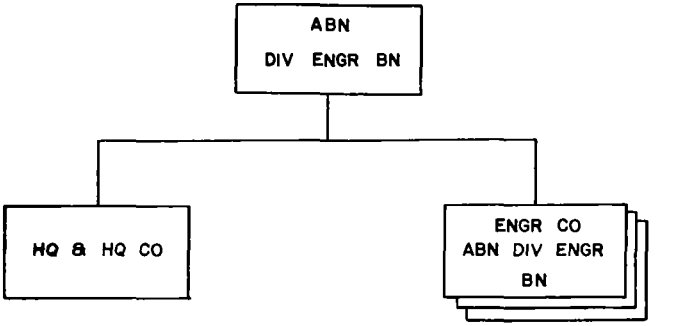


Figure 309. Organizational chart, infantry division engineer battalion.

by means of general engineer work and to reinforce the divisional engineer battalions when required.

d. Engineer Float Bridge Company. The float bridge company mission is to provide personnel and equipment to load, transport, maintain, and offer supervisory assistance in the erection of tactical stream crossing equipment.

e. Engineer Panel Bridge Company. The mission of the panel bridge company is identical to



STRENGTH	OFF 35	WO 2	EM 600	AGG 637			

MISSION TO INCREASE THE COMBAT EFFECTIVENESS OF THE AIRBORNE DIVISION BY COMBAT SUPPORT AND GENERAL ENGINEER WORK AND TO UNDERTAKE AND CARRY OUT AIRBORNE INFANTRY COMBAT MISSION WHEN REQUIRED.

***Figure** 310. Organizational chart, airborne division engineer battalion.*

that of the float bridge company with the exception that the bridge types are different.

f. Engineer Light Equipment Company. The mission of the engineer light equipment company is to operate and maintain a concentration of construction equipment in support of engineer combat units.

g. Engineer Brigade (shore assault). The engineer brigade (shore assault) provide specially

qualified planning assistance to the corps Commander and his staff for amphibious or shore-to-shore assaults involving multiple assaulting divisions. It has no organic units, but is capable of coordinating the organization and training of one to four division shore parties and of controlling their operations in the corps stage of amphibious or shore stage of amphibious or shore-to-shore operation.

h. Engineer Group (shore assault). The engineer group (shore assault) with its organic units provides command and control elements and equipment for a division shore party and basic nuclei for the brigade landing team. The shore assault group organization consists of—a headquarters and headquarters company, three engineer companies (shore assault), and one engineer company (amphibian assault). The engineer group (shore assault) is assigned to the field army as required for special operation.

3. Combat Service Support Units

Engineer construction, maintenance and supply, and topographic units are generally classified as service support units. They differ from the combat support units in that they support the combat forces *indirectly* by construction and allied activities in the rear area rather than by working in direct contact as do combat support units. Additionally, they have lighter armament, less mobility, less elaborate communication equipment, and more specialized technical equipment than do combat support units.

a. Engineer Brigade. The engineer brigade performs large-scale construction operations within the communications zone, including the establishment of bases and lines of communication. The capabilities of the brigade (normally assigned to the communication zone or to a separate task force) vary with the number and types of units assigned or attached. A typical brigade may include three to five contruction groups, and a varying number of other types of construction and construction support units engaged in large-scale construction operations. and related activities.

b. Engineer Construction Group. The engineer construction group performs large-scale, coordinated engineer construction operations. It may be assigned to a field army or communication zone and may be further assigned to an engineer brigade. The capabilities of an engineer group depend on the number and type of component units.

c. Engineer Construction Battalion. The mission of the engineer construction battalion in a theater of operations is to construct and rehabilitate roads, airfields, pipeline systems, structures and utilities for the army and the air force in the communications zone, and rear areas of combat zone. The battalion assists in emergency recovery operations and defends construction sites during construction.

APPENDIX III
METRIC CONVERSION TABLE

Inches to millimeters		Inches to centimeters		Feet to meters		Feet to meters		Miles to kilometers	
1/16"	1.52 mm	10"	25.40 cm	1'	0.30 m	200'	60.96 m	1/4 mi	0.40 km
1/8"	3.18 mm	20"	50.80 cm	2'	0.61 m	300'	91.44 m	1/2 mi	0.80 km
1/4"	6.35 mm	30"	76.20 cm	3'	0.91 m	400'	121.92 m	3/4 mi	1.21 km
3/8"	9.84 mm	40"	101.60 cm	4'	1.22 m	500'	152.40 m	1 mi	1.61 km
1/2"	12.70 mm	50"	127.00 cm	5'	1.52 m	600'	182.80 m	2 mi	3.22 km
5/8"	15.88 mm	100"	254.00 cm	6'	1.83 m	700'	213.36 m	3 mi	4.83 km
3/4"	19.05 mm	120"	304.80 cm	7'	2.13 m	800'	243.84 m	4 mi	6.44 km
7/8"	22.22 mm			8'	2.44 m	900'	274.32 m	5 mi	8.05 km
1"	25.40 mm			9'	2.74 m	1000'	304.80 m	6 mi	9.66 km
2"	50.80 mm			10'	3.05 m	2000'	609.60 m	7 mi	11.27 km
3"	76.20 mm			20'	6.10 m	3000'	914.40 m	8 mi	12.87 km
4"	101.60 mm			30'	9.14 m	4000'	1219.20 m	9 mi	14.48 km
5"	127.00 mm			40'	12.19 m	5000'	1524.00 m	10 mi	16.09 km
6"	152.40 mm			50'	15.24 m				
7"	177.80 mm			60'	18.28 m				
8"	203.00 mm			70'	21.34 m				
9"	228.60 mm			80'	24.38 m				
10"	254.00 mm			90'	27.43 m				
				100'	30.48 m				

APPENDIX IV

PROFICIENCY TESTS FOR ENGINEER SOLDIERS

In any future wars, whether they be general, limited, or cold wars, you have an increasingly important role. You are trained to fight; but just as important, you are trained to do all types of engineering work required to aid the advance of our troops and to stop the advance of the enemy. The uncertainties of war require every engineer soldier to know the fundamentals of every branch of military engineering. For example, you must know how to place a demolition charge that will be sure to go off when you fire it. In a fast moving situation, you may find yourself manning a rocket launcher or a machinegun even though you are not a regular member of the crew. You must know and be proficient in engineering and combat principles.

The development of your abilities as an engineer soldier has an important bearing on your progress in the Army. The proficiency tests that follow give you a chance to check up on what you have been taught and to review the things you should know.

CHECKLIST NO. 1—GENERAL

1. What information would you give the enemy, if captured?
2. What are the eleven General Orders for guards?
3. Give the Fighting Man's Creed.
4. What is Article 15 of the Uniform Code of Military Justice?
5. How many line companies are there in an Airborne Engineer Battalion?
6. How many line companies are there in an Armored or Mechanized Infantry Division Engineer Battalion?

CHECKLIST NO. 2—UNIT ORGANIZATION AND EQUIPMENT

1. What kind of bridge is organic to an Airborne Engineer Battalion?
2. What pneumatic tools are there with the air compressor?
3. For what purposes are they used?
4. Name the tools that are carried in the—
   a. Squad pioneer set.
   b. Squad carpenter set.
5. What is an adz, and what is the proper method for using it?
6. What is the proper method of using a two-man crosscut saw?
7. What types of communication equipment are found in your platoon?

8. What type and how many crew-served weapons are in your platoon?
9. What means of transportation is organic to your organization?

CHECKLIST NO. 3—BRIDGES

1. Define the following bridge terms—
   a. Abutment.
   b. Approach.
   c. Truss.
   d. Girder.
   e. Pier.
   f. Suspension.
   g. Chess.
   h. Bents.
   i. Cap.
   j. Curb Riser.
2. Identify the following parts of pontons, assault, and reconnaissance boats:
   a. Gunwale.
   b. Capstan.
   c. Bow.
   d. Transom.
   e. Bulkhead.
   f. Paddle.
   g. Oar.
   h. Stern.
3. Where are rocking rollers used?
4. What is meant by the term "Double-Double Bailey"?
5. A "38-foot dry gap" bridge is constructed from components of what?

6. What is the purpose of a launching nose?
7. What is a bridle line?
8. Describe the operation of a trail ferry.
9. Demonstrate how to construct an expedient type raft with your organizational equipment.
10. Descibe the pattern for placing balk on the M4T6 bridge.

CHECKLIST NO. 4—CAMOUFLAGE

1. Describe how you would tone down your skin.
2. Name the factors of recognition.
3. Describe how to camouflage your shelter half.
4. Demonstrate the patterns used for garnishing flattops and drape nets.
5. Describe how you would observe from—
   a. The inside of a house.
   b. Behind a wall.
   c. Behind a tree.
6. Describe how you would avoid making obvious vehicle tracks leading into a bivouac area.
7. What is the main disadvantage of using cut foliage as a natural camouflage material?
8. Describe how you would cross a skyline.
9. What field expedients can you use for skin tonedown if issue face paint sticks are not available?
10. What is the difference between "cover" and "concealment"?

CHECKLIST NO. 5—DEMOLITIONS

1. Know precautions to be taken before and during firing of a charge.
2. Know precautions to be taken in event of a misfire.
3. Know how to prepare and light safety fuze, using safety match; fuze lighter.
4. Demonstrate how to prepare a cap and safety fuze for firing.
5. Explain the difference between safety fuze and detonating cord and identify each.
6. Demonstrate how to join two pieces of detonating cord.
7. Demonstrate how to make a series connection of electrical caps; a parallel circuit.
8. Describe how to test a circuit by use of the galvanometer.
9. Demonstrate how to fix a demolition charge to—
   a. A rail.
   b. A post or tree (internal or external).
   c. A girder.
   d. A concrete beam.
   e. An I-beam.
10. Demonstrate how to prime a block of TNT nonelectrically; electrically.

CHECKLIST NO. 6—ENGINEER RECONNAISSANCE

1. Estimate height of a building or tree (within 10 percent error).

2. Measure height of building or tree (within 5 percent error) by comparing shadow cast by object with length of your own shadow.
3. Point out on a map likely places to look for—
   a. Sand.
   b. Gravel.
   c. Timber.
   d. A quarry site.
4. What does the term gradient mean?
5. Demonstrate your ability to read the road classification formula.
6. Be able to estimate velocity of a stream or river in feet per second.
7. Be able to identify the different type trusses used in bridge construction.
8. Convert kilometers to miles and vice versa.

CHECKLIST NO. 7—FIELD FORTIFICATIONS AND OBSTACLES

1. Know how to build a wall revetment.
2. Know how to build a double apron fence.
3. Demonstrate how to make a top eye tie on a screw type picket.
4. Demonstrate how to make an intermediate eye tie on a screw type picket.
5. Describe how to site a log hurdle.
6. Know what an abatis is and how to prepare one.
7. Name three expedient type road blocks.
8. Know how to construct a bamboo whip.

9. Know the dimensions for a one-man **foxhole.**
10. Know how to construct a high wire entanglement.

CHECKLIST NO. 8—CBR

1. What is the gas alarm for your unit?
2. Know how to put on, adjust, test, and remove a gas mask properly.
3. Know the field identification of the following gases by smell:
   a. Mustard.
   b. Lewisite.
   c. Chlorine.
   d. Phosgene.
   e. Chlorpicrin.
   f. Tear gas.
   g. Adamsite.
4. Which gases are vesicants? Which are lung irritants? Which make you cry?
5. What first-aid measures will you take for a casualty by a vesicant gas? By a lung irritant gas?
6. What measures would you take if you were in the open and observed a nuclear blast?
7. What is meant by the term "flash to bang time"?
8. What is residual fallout?
9. What action would you take if you noticed drops of an oily liquid on your person after an artillery barrage?
10. What is atropine used for?

CHECKLIST NO. 9—RIGGING

1. Know how to coil and uncoil rope.
2. Know how to tie the following knots and their uses:
   a. Bowline.
   b. Prusick.
   c. Sheep shank.
   d. Clove hitch.
   e. Fisherman's bend.
   f. Round turn and two half hitches.
   g. Mooring hitch.
   h. Square knot.
3. Know how to whip the end of a rope; mouse a hook.
4. Know how to make a short splice; an eye splice.
5. Name parts of a set of double blocks; know how to reeve them.
6. Know how to make lashings for gin pole, shears, and tripod.
7. Know where to fix guys to shears and gin pole.
8. Know precautions to prevent damage to wire rope.
9. Know how to make a 3–2–1 picket.
10. Know how to install wire clips.

CHECKLIST NO. 10—MAP READING

1. Know how to determine grid coordinates on a point indicated on a map.

2. Know how to orient a map with and **without** a compass.
3. Given two points on a map, scale the road distance between them in miles.
4. Be able to identify by contour lines—
   a. A hill.
   b. Steep slopes.
   c. Ridge lines.
   d. A saddle.
   e. A cut.
   f. A fill.
   g. Marsh.
5. Be able to identify on a map—
   a. Railroads.
   b. Highways.
   c. Crossroads.
   d. Woods.
   e. Bridges.
   f. School.
   g. Mines or quarries.
   h. Trails.
6. What is the difference between magnetic, true, and grid north?
7. Be able to determine north by watch and sun; by compass; by north star and big dipper constellation.
8. Know how to determine the azimuth from one point to another on a map; on the ground.
9. Know how to determine a back azimuth.
10. Know how to determine slope and visibility from a contour map.

CHECKLIST NO. 11—ROADS

1. Know how to place standard types of landing mats.
2. Know the function of a drainage system.
3. Know characteristics of a road made with—
   a. Wire mesh.
   b. Corduroy.
   c. Plank tread.
   d. Gravel.
   e. Chespaling.
   f. Army track.
4. Know the following items of equipment and what they are used for—
   a. Scraper.
   b. Angledozer.
   c. Scarifier.
   d. Rollers.
   e. Dragline.
   f. Rooter.
5. Know the meaning of the following terms in relation to military engineering—
   a. Clearing.
   b. Grubbing.
   c. Subgrade.
   d. Aggregate.
   e. Crown.
   f. Shoulder.
   g. Culvert.
   h. Riprap.
   i. Scour.
   j. Revetment.
   k. Gradient.
   l. Headwall.

CHECKLIST NO. 12—ROUGH CARPENTRY

1. Know how to lay out a right angle by the 3–4–5 method.
2. Know how to square abutments with the centerline of a bridge.
3. Know how to plumb an upright, using a level.
4. Be able, using a carpenter's square, to mark a timber for a 45° cut.
5. Know how to make the various timber splices, and joints.
6. Know the different type of heads on screws.
7. Know the approximate length of the different size of nails.
8. Be able to identify the parts that make up the substructure of a building and their purpose.
9. Be able to name the parts of a roof truss and their purpose.

CHECKLIST NO. 13—HANDTOOLS AND THEIR USES

1. Know correct use of pick and shovel.
2. Know proper use of gooseneck wrecking bar.
3. Know proper use of an adz; a hatchet.
4. Know proper handling of a chopping ax; a handsaw; a two-man saw.
5. Know how to use a peavey in handling a log.
6. Know how to fell a tree in a given direction.
7. What is the difference between a crosscut and a ripsaw?

8. Know how to sharpen an ax.
9. Know how to properly operate the gasoline-driven chain saw.
10. Know how to operate properly the following pneumatic tools—
    a. Timber chain saw.
    b. Clay spade
    c. Rock drill.
    d. Circular saw.
    e. Air hammer.
    f. Pavement breaker.

CHECKLIST NO. 14—WEAPONS

1. Disassemble and assemble your basic weapon.
2. Perform general disassembly and assembly of the machinegun, M60.
3. Give a fire command used by the crew of an M60 machinegun delivering fire on a fixed target.
4. Explain the following terms used in conjunction with the characteristics of fire of the M60 machinegun—
    a. Trajectory.
    b. Cone of fire.
    c. Beaten zone.
    d. Danger space.
5. Explain the following classes of fire—
    a. Frontal fire.
    b. Flanking fire.
    c. Oblique fire.
    d. Enfilade fire.

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